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ABSTRACT

Further developing a theme that has characterized several recent EDUCOM conferences, the 1974 EDUCOM Fall Conference focused on "Computing and Networks in Higher Education." Included in the conference program were papers and discussions on approaches to solving the organizational and financial problems of networking used in both the United States and Canada. The specific topical sections were: (1) national computing policies, (2) integrating CATV and computing instruction, (3) computers and the learning process, (4) networking for instruction, (5) management of systems and institutions, and (6) communication and innovation. (Author/DGC)

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NORTH AMERICAN PERSPECTIVE

EDUCOM
FALL 1974

U.S. DEPARTMENT OF HEALTH,
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PROCEEDINGS
of the
EDUCOM
FALL CONFERENCE

October 16 - 18, 1974
Toronto, Ontario

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Preface

Further developing a theme which has characterized several recent EDUCOM conferences, the 1974 EDUCOM Fall Conference focused on Computing and Networks in Higher Education. A new emphasis was given to the meeting by including in the program discussion of approaches to solving the organizational and financial problems of networking used in both Canada and the United States. Location of the conference in Toronto enabled a greater number of Canadian college and university representatives to participate in the Conference. Seventy-eight of the conferees represented Canadian institutions.

Drawing both program committee members and specific topics from both sides of the border, the conference was structured as a logical sequence of sessions exploring aspects of communications technology, applications of computing and instruction, computer networking, and applications of computing for administrative functions. The papers presented during the remainder of the conference follow and the document closes with a version of Gordon Thompson's banquet address edited for publication.

Further information on any of the applications or policies described in these chapters can best be obtained by writing or calling the author of the presentation. Names and addresses of all conference participants including speakers are listed in Appendix F.

Sincere thanks are due to the conference program committee which conceived and executed the excellent program reflected in these pages. Co-chairmen shared the leadership responsibility for the committee: John Wilson, Director of the Computer Center, University of Toronto; and

James Emery, formerly Chairman of Decision Sciences, The Wharton School, University of Pennsylvania who has now become the Executive Director of the Planning Council on Computing in Education and Research. Other members of the Committee were: J. Wesley Graham, Department of Computer Science, University of Waterloo, David Macey, Director of Computer Coordination, Council of Ontario Universities and John Rockart, Associate Professor of Management, Massachusetts Institute of Technology.

Henry Chauncey

Introduction

The EDUCOM Fall 1974 Conference was intended to develop a theme that has run through a number of EDUCOM conferences previously: Computer Networking for Higher Education. With the location of the conference in Toronto, the Program Committee hoped to highlight those parallel and unique aspects of Canadian experiments with computer networking and compare them to United States experience with similar technologies. In contrast to some earlier meetings, the 1974 Fall Conference was planned as a single program in order to emphasize the logical sequence of sessions within the conference. Beginning with a tutorial on the State of the Art in Computer Communications, the conference program included national policies for sharing computing resources in higher education, computers and the learning process, use of computing for instruction both as a stand alone technology and in conjunction with cable television, and administrative computing.

In the keynote address, George Glaser, current President of the American Federation of Information Processing Societies, challenged conferees to evaluate existing university programs for training computer professionals. In a delightful yet substantive banquet address, Gordon Thompson outlined the model of communication innovation that researchers at Bell Northern Research have developed to assist them in assessing communications innovations. Both the keynote and banquet address are included in this volume.

Most of the papers presented at the Conference, edited for publication, are included in the following pages. Part One, "National Computing Policies," opens the volume with a broad view of policies in Canada and

the United States with respect to the sharing of computing resources. The closing paper in Part One, "Toward a Facilitating Network," outlines plans for a facilitating network for computing in higher education that will guide the work for the Planning Council on Computing in Education and Research.

Part Two, "Integrating CATV and Computing in Instruction," includes papers that discuss the combined use of computers and cable television for instruction at the United States Military Academy, United States Naval Academy, and the University of Akron.

"Computers and the Learning Process" is the focus of Part Three. Included in this section are papers outlining a conceptual model for assessing the use of computers in the learning process and reports on actual use of computers for instruction in Massachusetts, North Carolina, and at the Ohio State University College of Medicine through the Tymeshare Network.

Part Four, "Networking for Instruction," gives the reader a close look at the hierarchical network developed by the California State University and Colleges that has been operational since 1973. Independent development of minicomputers is also explored.

"Management of Institutions and Systems" is addressed in Part Five at two levels: the organization of the data processing function within a large organization and the use of computing systems for university management.

It is evident that educators in Canada and the United States are working to develop a rational approach to sharing computing resources. Models of the sharing process are being developed and tried. Experience in the province of Ontario, as reported in Dr. Meincke's paper, may be particularly relevant to United States educators. Most papers discuss communications as a broader concept than computer networking. Although run by computers, communications networks include far more than the transmission of computer programs and data that constitute the bulk of network traffic at the present time. For those who could attend, as well as for others who will take part in the conference only through this publication, the papers collected in the following pages should provide a valuable information resource on the state of computing and computer networking in Canada and the United States in 1974.

*James Emery
John Wilson
Conference Co-Chairmen*

Keynote

EDUCATION AND COMPETENCE: The Odd Couple

by George Glaser

I am honored, and pleased, to have this opportunity to Keynote the Tenth Annual EDUCOM Conference. I'd like to discuss with you what I believe to be a very serious problem for all of us who are concerned with computing, whether in the academic world, in industry, in service organizations, or in the government.

My specific concern is that the increasing demand for computer-based services and the relentless pace of technological development are outrunning our ability to provide and maintain an adequate supply of high-quality professionals who can apply computer technology effectively.

In my view, this poses a serious and growing problem for all of us in the computer industry, and it raises some particularly tough questions for educators:

- Has the educational system been part of the problem?
- How can it contribute to the solution?
- What is the role of the computer scientist?
- What other disciplines are needed?
- Who should provide them?

I wish I had crisp and convincing answers to these questions that I could put forth here today, but I don't. I do however, have some observations I'd like to share with you some of them based on personal experiences and others based on my understanding of what our colleagues are saying and writing.

First, a word about my biases and background: I'm an engineer by virtue of my formal education; that makes me a pragmatist, a bias that I consider unashamedly to be virtuous. I also am an ex-analyst/programmer who cut his teeth in a business data processing installation; the prefix "ex" applies because most of my hands-on-experience with computers is somewhat dated but, at the same time, it qualifies me to make first-hand observations on the technological obsolescence of individuals.

And I have been a consultant in industry for a number of years during which time I have been exposed to a reasonably broad cross-section of data processing users and their problems.

I would now like to draw on both my biases and my background which I suspect are quite different from those of many of you in my role as keynoter.

Although I know only a few of you personally, I understand that you hold administrative positions in colleges or universities, including the responsibility for computing activities. I hope that my understanding is correct, because I want to suggest some changes that I think need to be made both by those in academia and those of us outside it.

Several weeks ago, I was asked to submit a title and abstract for this address. I picked as my title "Education and Competence: The Odd Couple". In doing so, I realized that I was suggesting that the relationship between Education and Competence was somewhat strained; and that's exactly what I intended to do. I did not, however, mean to suggest that the two were unrelated for obviously they are, or should be, related very closely. Yet I believe there is a mismatch that not only is unfortunate but also unnecessary.

I should clarify my terms because I am speaking of Education and of Competence in a very particular context. My definition of Education includes that formal classroom training leading to a bachelor's, or higher, degree in Computer (or Information) Science. Competence, as I use the term here, is that very special combination of knowledge and skill required to conceive, evaluate, design, build, install, and maintain economically justified business data processing applications in an environment that often is hostile, ignorant, poorly managed, inadequately funded, or all of the above. Using those definitions, I do then assert that Education and Competence are an Odd Couple.

THE ENVIRONMENT

Allow me first to set the stage. As duly note by EDUCOM's Planning Council on Computing in Education and Research, the state of the art in computing has made steady progress during the fifteen years starting about 1955. (10) The Council cites as evidence the following: "... larger computers, specialized programs, massive data bases, and advances in

communications technology." In that sense, I agree that we have indeed made progress.

But other changes have taken place in the same time period; for example, we have witnessed dramatic growth in the number of machines installed, the range of their size and power, and the sophistication of those who use and depend on them. And with this growth has come enormous pressures on the computing profession to provide large numbers of well-qualified individuals who can put these machines to work in useful and socially acceptable ways.

Estimates vary widely on the number of programmers and analysts today, and they vary even more widely on the number needed in future years. For example, the Bureau of the Census reports 164,000 programmers in the U.S. in 1970, and the Department of Labor projects a need for 400,000 by 1980, an increase of 150% in ten years. Other reports call for 320,000 programmers by 1980 and 640,000 by 1985, requiring an additional increase of 100% in the following 5 years. I'm not competent to judge the validity of these estimates but, for the sake of argument, let me ask you to accept a conservative estimate that we will need approximately two to three times as many programmers ten years from now as we have today, and that the number of analysts needed will increase correspondingly.

The latter question arises because information systems now are considerably more complex than they were just a few short years ago. In spite of our acknowledged technological progress, I believe that it now takes more, not less, skill to design a system, to get it on the air, and to keep it running smoothly.

In my view, we are now very nearly at the point where we are unable to manage the complexity that surrounds our current technology, and there is a distinct possibility that we will not be able to manage the complexity that soon will engulf us.

Complexity is not a new phenomena. Both mathematicians and scientists thrive on it because they have learned to deal reasonably comfortably with complexity in its classical forms. For example, when mathematicians are faced with a complex problem, they break it into simpler ones for which they have tools; they know how to model complex phenomena in useful and satisfactory ways.

Scientists, too, have learned to deal with complexity. Even when physical laws are not known explicitly, the scientist can still observe, record, and analyze the results of his experiments, and from them draw reasonable inferences.

Medicine is another field where complexity can be dealt with even though there are enormous gaps in our knowledge of physiology and neurology.

But there is another, less tractable, form of complexity that confounds us by not responding to the classical tools of mathematics and science. It is

called arbitrary complexity, a term used by Professor Frederick P. Brooks, Chairman of the Computer Science Department at the University of North Carolina, who graciously loaned it to me for this occasion. Arbitrary complexity results when a very large number of independent decisions and events, occurring over long periods of time, produce a cumulative and unpredictable effect on the environment. Arbitrary complexity confounds both the mathematician (whose models do not work) and the scientist (whose experiments do not yield results of adequate stability).

In the field of computing, arbitrary complexity is found in two areas: 1) operating systems, and 2) business data processing. Complexity in the former is arbitrary because it is literally impossible to know precisely what is going on within an operating system under any realistic set of conditions. Similarly, business data processing systems are characterized by arbitrary complexity because the environments in which they must function are so intimately linked with the behavior of literally thousands of individuals whose environments, in turn, have been and will be strongly influenced by the behavior of many more thousands of still other individuals. It is this complexity, which is ever increasing and which threatens at times to become overwhelming, that places on us a requirement for ever larger numbers of well-trained professionals who not only understand our technology but who can apply it effectively.

THE SCARCITY OF COMPETENCE

Our ability to undertake more ambitious projects, and thereby to solve more complex problems, is — and will continue to be — limited by our ability to muster an adequate force of skilled manpower.

In my view, we find ourselves in the following position:

- There are a distressingly large number of poorly-qualified people at all levels, and particularly in user development organizations.
- Those who are now competent are being less so every day as technological developments continue at an overwhelming rate.
- Our universities are turning out far too few computer-oriented problem solvers.
- The long-term career prospects for data processing professionals in most user organizations are not sufficiently promising to attract the talented young men and women who can add to, and strengthen, our supply of available manpower.
- We are having a painfully difficult time achieving the level of professional maturity that would help stimulate and reward the continued self-renewal of individual competence.

I made these points in my Keynote Speech at the National Computer Conference in Chicago last May. (3) The one I'd like to discuss further today is my statement that universities are turning out far too few computer-oriented problem solvers.

Let me begin by acknowledging — and applauding — the fact that the quality and quantity of computer science education in this country, and around the world, has developed strongly. Unfortunately, a formal education in computer science as found in most academic institutions today is not an adequate — nor even an appropriate — background for those who must design and install large-scale computer systems in business environments.

Computer science deals with the science of computing — a science that is still in its infancy and that offers attractive challenges to those dedicated to teaching and research.

But the successful *application* of computer science, on the other hand, requires skills, training, and a point of view quite different from that of the scientists who discover and formulate its principles.

I believe this difference in point of view was clearly brought out by Dean Donald Carroll of the Wharton School in his article "Management Information Systems" presented at the EDUCOM Fall Conference last year. (2) Dean Carroll said "Eight years ago as an academic concerned with management information systems, I could have elegantly demonstrated, practically proved mathematically, the possibility of generalized MIS for university administration. Four years ago, as general manager of a systems development firm, I would have been delighted to present any of you with a proposal for a generalizable management information system, but probably not at a fixed price. Now, as an academic administrator, I am considerably less optimistic, but not totally without hope. It is difficult to say whether it is age, fiscal responsibility, or conscience that has made a coward of me."

I doubt that Dean Carroll is a coward but I am not surprised to find that his point of view changed as he moved from academic to general manager of a systems development firm to academic administrator.

In a similar comment on viewpoint, Dr. Harlan Mills of IBM has suggested that we take a lesson from the commonly-used expression "the Practice of Medicine." (5) Mills suggests that we start by recognizing that medical schools teach various aspects of this practice, such as surgery and radiology, while other schools teach the more basic scientific aspects, such as biology, zoology and chemistry. These latter, although of deep interest to the practice of medicine, do not address it directly. Mills goes on to argue that computer science does not address the practice of computing, even though it addresses subjects of deep interest to it.

If I may add to Mills' arguments: Were it not for our knowledge of biology and chemistry, no responsible physician would dare undertake the kinds of surgery that are quite commonplace today. Yet we call upon surgeons, not biologists, to take out our appendix. I would have similar misgivings about asking most switching theory specialists to design and install an on-line message switching system to serve a company for which I was responsible.

What we desperately need are professional problem solvers, trained to practice computing — the kind of problem solvers who fully understand the burdens of being an innovator. But for the large majority of graduates of existing computer science programs, the innovator role is distasteful and frustrating because as you no doubt are well aware, the innovator has as his enemies all those who prospered under the old regime, and as lukewarm supporters all those who might prosper under the new.

THE CURRICULUM ISSUE

An enormous amount of effort has gone into the development of recommended curricula for the computer field, much of it led by the Association for Computing Machinery which, through its volunteer committees, has made several outstanding contributions.

Perhaps best known is Curriculum 68, in which the ACM Curriculum Committee on Computer Science presented its recommendations for academic programs in computer science. (6) In 1972 and '73 respectively, the ACM Curriculum Committee on Computer Education for Management presented its recommendations for graduate and undergraduate professional programs in information systems. (7,9) Still others have proposed addenda to the ACM work; one such proposal is for a course on information systems administration. (8).

From my point of view as a non-academic, the ACM recommendations make very good sense. In particular, I am pleased by the recognition of a need for an organizational concentration at both the undergraduate and graduate level in the information systems curriculum. I am further reassured to find such words as "usability, operability, and maintainability" cited as attributes which systems must have in order to meet the needs for human interaction. And I am still further reassured to find that the categorization of requisite knowledge and abilities begins with "People" as the first item, and that the authors define "People" as one of three fundamental categories (the other two being Models and Systems).

The report on graduate programs in information systems pointed out that few of the recommended courses existed in universities at that time (May 1972), either in schools of business administration, departments of computer science, or elsewhere. Since that date, certain schools have indeed established such courses and others are in the process of doing so.

This progress is most encouraging and it confirms the value of thoughtfully developed curricula. But such a curriculum, while absolutely necessary, is not by itself a sufficient response to the need.

Attitudes must change as well, and clearly they have not done so universally. And where attitudes have not changed, the computer science fraternity has an obligation to tell the students graduating from their programs as computer scientists and their prospective employers that they

are not being trained for work in industry. Such a frank conversation with the graduating computer scientist wouldn't really solve industry's problem, but it might at least reduce the confusion in the minds of both parties.

I recently corresponded with a computer science professor who was concerned with shaping the curriculum at the university at which he teaches. In response to his request for comments, I expressed my concern that many university computer science departments were staffed with teachers who had had little or no experience with the street fighting that their students would find in the world of tight budgets and onerous deadlines, and thus that the teachers were poorly equipped to prepare them for it. I also told him that I felt that too many computer science departments are training cello players for a Fourth of July parade, and that in my view, it's damned difficult to play a cello while walking down the middle of the street in the hot sun.

In reply, my correspondent assured me that he took my remark to heart, and expressed the hope that he could gain such experience by spending time working outside the university. He added that he had discussed doing so with his colleagues and that from those discussions he had concluded that there were three main reasons why many teachers do not get such experience. I quote him here: "First, many do not have the inclination. Second, those who do have the inclination may consider it more important to spend their time in an academic activity which contributes more to their academic advancement; and third, those who decide they should spend time working for industry do not feel confident an employer would be interested in hiring them on a temporary basis."

I'd like to comment on the three reasons he cited. First, those individuals who do not have the inclination to get such experience should not teach courses in which the insights that such experience would bring are badly needed. Second, those who consider it more important to spend their time in an academic activity which contributes more to their academic advancement offer quite a sad commentary on the process of academic advancement, for if the activities which lead to improving the quality of education for their graduates are indeed in conflict with those which enhance the individual teacher's possibilities for advancement with his community, then academic advancement is distinctly counterproductive. Third, those who do not feel confident an employer would hire them on a temporary basis may be correct. Realistically, it would not be a simple matter to arrange for individuals to move freely between the academic environment and the industry environment, but perhaps we should try to make it so.

Both parties should benefit from such a program in a direct way. The teachers could gain invaluable experience; and industry could contribute more directly to the education of future graduates while, in the short term, gaining new insights and ideas for the solution of its problems.

For those of you who would like to consider this and related ideas further, I recommend that you read, "On the Preparation of Computer Science Professionals in Academic Institutions" by J. A. Archibald, Jr. and M. Katzper. (1) This and several other excellent papers on various aspects of computer science education were presented at the National Computer Conference last May (NCC '74). Among the recommendations made at the NCC to improve the effectiveness with which computer science graduates can assume responsibilities in industry is that individuals be encouraged to acquire undergraduate training in an area other than, but related to, computers. To quote the Archibald/Katzper paper: "Industry certainly needs people with (1) an understanding of industrial problems, (2) an understanding of computers, and (3) fresh, new ideas."

A graduate with a basic understanding of industrial problems, whether acquired in an engineering or business administration program and who, in addition, has an understanding of computers (and an understanding of their limitations) could be very effective in industry. Teaching students to produce fresh new ideas is, no doubt, the most challenging of the three, but not the point at issue here.

In another NCC '74 paper, Gopal K. Kapur put his criticism bluntly: "One of the greatest enigmas is the gross failure of colleges and universities to involve themselves in the development of business data processing science." (4) Yet following this harsh indictment (and after giving his reasons for making it), the author concludes: "In the long-run, colleges and universities are the only hope for well-qualified business data processing professionals".

I agree completely. You are our only hope. But I am not satisfied that the significance of the problem is fully appreciated in academic circles or that those who are in a position to take the necessary steps to solve it are prepared to do so.

SOME POSSIBLE SOLUTIONS

The scarcity of competence problem won't be solved easily or quickly, but it won't ever be solved unless we go to work on it. To this end, AFIPS and its Constituent Societies have launched several activities that we believe will help and we're considering still others that could have significant long term impact.

The AFIPS Professional Standards and Practices Committee, chaired by Donn Parker of Stanford Research Institute, will propose to the AFIPS Board of Directors at its meeting next month a long-range plan that will include the following elements:

- Job descriptions
- Self-assessment
- Certification
- Preferred design practices

AFIPS has already developed and published comprehensive job descriptions for computer programmers. We view these as basic to any efforts towards self-assessment and certification. Those of you who are considering additions to your curriculum hopefully would find them useful in assessing what qualities, skills, and attributes have been identified by working programmers and their managers as most important. A follow-on project to prepare similar job descriptions for systems analysts is now underway. The AFIPS Board will be asked to approve the balance of this project. Eventually, we hope to develop job descriptions for the majority of occupations in the computer field.

The second element of the plan that will be discussed with the Board of Directors is self-assessment. We are considering a self-assessment program such as that currently offered by the American College of Physicians in which over 10,000 physicians are enrolled. In such a program, any individual who cares to do so may take an unsupervised test and submit his answers for grading. He subsequently is told which questions he answered correctly and how well he scored relative to others taking the same test. His name and score remain anonymous, however, since the purpose of the test is self-assessment. Since self-assessment is a major undertaking, we will in all probability eventually propose a joint effort with one or more of our Constituent Societies.

The third element is certification. We know that certification is a controversial matter but on balance I believe it has merit. The Institute for the Certification of Computer Professionals now has the active support of ACM, the Computer Society of the IEEE, the Data Processing Management Association, and several other professional societies. Since all three of these major societies also are members of AFIPS, we must consider what role, if any, AFIPS should play in the work of ICCP.

The fourth element is the publication of review manuals. Although it was originally hoped that we could suggest means for certifying computer systems in some way, we have since abandoned that idea. Instead, we expect to prepare a series of manuals that pose questions which can be used to evaluate various aspects of their design. The first of these manuals, dealing with Security, has just been published and we hope to distribute it widely. Although it may seem somewhat mundane that AFIPS is in the business of preparing checklists, we believe that the Security Manual will prove to be of considerable value to many installations throughout the country.

This should give you some idea of our current and planned activities. We certainly hope they will be successful and intend to work hard to make them so.

But even if our efforts are successful beyond our wildest dreams, the fundamental problem will be solved only when there is a steady flow of well-qualified individuals from the formal educational system into user organizations. And that is not a problem that professional societies can

deal with directly. They can only raise their voices and, hopefully with the help of their members who also are members of the academic community, bring individual influence to bear on those who are making the key decisions on the orientation and content of academic programs.

I posed several questions at the outset of my talk. Let's review them:

- *Has the educational system been part of the problem?* In my view, Yes. The educational system is providing nicely for a body of competent computer researchers and teachers, but has done little to provide for the needs of those who must apply computer technology, particularly in a business environment.
- *How can it contribute to the solution?* By recognizing the special skills required of the problem-solving practitioner and then by adopting programs that will produce graduates who can effectively assume that role.
- *What is the role of the computer scientist?* To advance the science of computing so that others can apply it.
- *What other disciplines are needed?* Economics, management organizational behavior, functional skills; in short, the ability to recognize a worthwhile application, design a system for it and make it happen.
- *Who should provide these disciplines?* The universities must teach the fundamentals. And for those who already have finished their formal education and who are so motivated, self-assessment, self-study, and continuing education seem most promising.

In summary, we have a serious and growing shortage of a precious resource. Unless we take drastic steps to alleviate it, we are going to find ourselves in the precarious position of having raised unrealistic expectations in the minds of computer users (including the general public) and then of being chronically unable to deliver to those expectations. And although we are certain to have even more powerful tools than we now have, the growth of an exciting profession could be stymied, or even permanently stunted, by our own short-sightedness unless we train a strong cadre of those who can apply our technology wisely and competently.

It's a tough problem. I don't think it will go away. Only you who are educators can solve it in a lasting way. I hope you will.

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Part I

**National
Computing
Policies**

Chapter 1

NATIONAL POLICIES FOR INFORMATION PROCESSING

by Calvin C. Gotlieb

BACKGROUND

There is no need in this forum to make the case for the importance of computers or to describe the growth that has been experienced, almost without pause for over twenty years, in their design, production and use. Computers play vital roles in industry, administration, education and government, and in many respects, the ways they are used and the ways they are seen by organizations and institutions in those spheres are very much alike in all countries, or at least in all countries which are at approximately the same level of economic and industrial development. But there are national differences in the way computers have penetrated into society and in the responsibilities that governments have acknowledged and undertaken with regard to them. Two facts are sufficient to illustrate that the position of computers in the United States is different than it is in other countries. First, the U.S.A. is, to all practical purpose, the only country with a substantial computer production industry in which, even allowing for the dominant role of IBM, there are diverse and successful competitors. Second, the U.S.A. is almost the only country sophisticated in the use of computers, which is not engaged in trying to formulate an overall national policy relating to the production and use of computers. Dr. Ruth Davis, Director of the Institute for Computer Sciences and Technology of the U.S. National Bureau of Standards, argues that

centralized planning with regard to computers in the United States would be restrictive and stifling, forcing growth and change in narrow directions at a time when there is still a great deal of innovation in the computer technology. (3) The lack of *overall* policy does not mean, of course, that no policy exists or is sought on special issues such as privacy, networks, standards or acquisition of computers within the government. Nor does it mean that there have been no advocates for more planning; calls for this have been voiced regularly, and there has been at least one book advocating a greater governmental presence in formulating policies for computers. (2) Whether the argument that diversity and strength of the U.S. computer industry is such that the industry would be impeded by attempts at overall planning is a valid one, or a rationalization, it is a fact that in the United States any federal bodies concerned with computers address themselves to special problems in a relatively narrow area over which they have jurisdiction.

In some other countries at least, the situation is different. The Japanese plan for intensive long term development of the "knowledge economy" places particular emphasis on computer technology. (13) In Canada there has been a continuing series of studies on computers for almost a decade, many of which originated in a department specially created to cope with the problems of new technologies like computers, satellites and cable TV. The United Nations has issued reports urging developing countries to formulate national policies with regard to computers, (4) and OECD has issued a series of reports on the computer technology and on comparative studies of policy. (9) Certain countries, notably the United Kingdom and France, have undertaken major support of their computer industries in ways which are quite different from the type of support found in the United States. National efforts at policy review and formulation and large scale financial support, arise out of the concern that the country is failing, or will fail, to get a fair share of the action in a crucially important development, if steps are not taken and national goals formulated and realized.

GOVERNMENTAL OBJECTIVES WITH REGARD TO COMPUTERS

Objectives which different governments have sought with regard to computers are conveniently summarized under three headings:

I. To use computers effectively in its own operations. In particular governments seek to use computers for administrative, planning and military application.

II. To promote an indigenous computer industry. This is a desired goal for a variety of reasons of which the most important are to:

- ensure effective national use of computers in administration, planning, industry, process control, education, etc.
- create jobs since computer based industries are growing exceptionally fast and they make intensive use of people with

relatively high levels of education, an important factor as the number of college graduates increases.

- *improve the balance of payments.* The alternative is higher imports as the number of computers increases.

III. *To direct and regulate computer growth so that:*

- *detrimental secondary effects are not experienced* like erosion of privacy, and large scale unemployment
- *benefits of technology are distributed fairly* between public and private sections, employers, and employees
- national controls are exercised on ownership of industry, data banks, and so on.

The methods available for promoting these objectives are those which governments usually have open to pursuing any goal such as passing legislation and spending money in a variety of ways.

- *Award grants and contracts* for: establishing new industries; setting up cooperative ventures between gov't/industry, universities/industry; research; or training and education.
- *Promote debate and research* through studies of policy analysis or marketing, conferences, or publications.
- *Adopt selective taxation policies*, like offering incentives to industry and companies which meet specified criteria, or applying tariffs and excess profits taxes to protect indigenous suppliers.
- *Apply purchasing policies* for its own acquisition or for supported installations like educational institutions and local governments.
- *Set up regulatory agencies applicable to* critical aspects of the the technology like communications; use of personal data; and data banks containing data of national importance on resources and people.
- *Create model operations* for personnel data banks, service bureaus, or special applications like planning and libraries.

THE CANADIAN EXPERIENCE

Before using Canadian examples to illustrate how the various instruments and methodologies just listed have been used by governments to achieve the three objectives named earlier. I hope it will be clear that there is no suggestion that in Canada we have had the most concerted or most successful attacks on these problems. Support of the computer industry for example has been much more continuous and important in Great Britain and in Germany, where both countries have sought to keep a national capability for designing, manufacturing and marketing main frames (through ICL in Great Britain and Siemens in Germany). Nor is there in Canada any organization which conducts research on all aspects, theoretical and practical of software, as is done in France by IRIA, or

which concentrates in computer use, applications and markets as does the Computer Usage Development Institute in Japan.

It is necessary to describe some aspects of the current political scene in Canada. For the last ten years the governments in Canada have been going through a redefinition of the relative powers of the federal and provincial governments in a kind of struggle which has occurred periodically in the United States, but which is comparatively new in Canada. This redefinition which was first pressed by Quebec, is being pursued with equal vigour now by other provinces — e.g. Ontario and Alberta. The British North American Act, which is the closest approximation to a constitution in Canada, allotted certain responsibilities and taxation powers to the provincial governments (e.g. for education, civil law, and the regulation of professions) and others to the federal government (criminal law, defence, interprovincial trade). In many areas where the delineation of responsibilities is far from clear, both provincial and federal governments are staking out claims. An example is communications channels as used in cable TV and computer networks. Although the federal government, through its specially created Department of Communications, has so far been the most dominant by launching satellites and conducting nation-wide studies, the provincial governments have not relinquished their claims to jurisdiction. Quebec, for example, is well on its way with a provincial computer network for education, where it has undisputed rights, and Ontario likewise has a strong educational TV network. These problems will not be settled in Canada until there is agreement on a new constitution in which the provincial and federal powers are renegotiated, an enormously difficult task which the present government has just indicated that it will tackle again. Although many important matters relating to computers cannot be settled yet, there has been a very long series of studies and reports, from which certain goals have emerged and actions initiated.

A second facet of the Canadian political scene is the strong nationalism which is apparent in the public attitudes to many issues. It manifests itself as a desire to foster and maintain a distinctive "Canadian" approach in such diverse matters as ownership of industries, resource management and the performing and creative arts. Although strong Canadian nationalism is most definitely *not* anti-Americanism, since in most activities the Canadian way of doing things is very similar to the practices in the United States, many Canadians show a noticeable reluctance to be associated in joint programs. It does not matter that in many of these areas, few persons, if anybody, can say what is different about how they are being done, or should be done in Canada as compared with the United States. There is nevertheless a concern that failure to keep a distinct Canadian operation might in the long run be detrimental to Canadian interests. As an example, I am certain that most Canadians would agree that any inventory of resources such as water or energy should be taken and

maintained separately in Canada, so that independent judgements can be made in negotiations which are eventually bound to be undertaken. But the feeling that data banks ought to be kept separate goes beyond this. Medical data on certain Canadians who have applied for life insurance are kept in a centralized data bank maintained by the Medical Information Bureau, Boston, on behalf of a large group of U.S. and Canadian-based companies. The reason for a shared file is obvious, since the discovery that a high risk applicant has failed to reveal information is of common interest. However, Canadian participation in the data bank has been questioned, at least to that extent that attention was drawn to it in reports on privacy undertaken by the federal government.(2,7) No recommendations were made suggesting that the files be separated, but the general uneasiness was clear.

With this background, I should now like to return to the three main objectives mentioned earlier.

Effective Use of Computers in Government Operations

In this area the goals are clearest, the methods for achieving it are best understood, and in the case of the federal government at least there is demonstrable progress along a planned path. An EDP master plan was issued by the treasury board in 1972 as an overall policy guide in which strongly decentralized approach has been adopted. The Central Data Processing Bureau, which for some years has been offering optional services to government departments, is not even mentioned and will clearly not play an important role. Instead two types of data processing centers are recognized, departmental and functional. Departmental centers in the main serve existing departments like National Revenue, RCMP, or Statistics Canada; Functional services, as the name implies, are more concerned with the type of application such as revenue collection, trade and transportation, or resource and environment. In a five year time-table for developing new functional services, the range of applications considered is impressive, and the plan shows a full understanding of the multiplicity of ways computers can be brought to bear on governmental operations. In 1974 the plan is well advanced. Several of the functional centers have been set up and newer publications describe how the services are to be administered.(10)

In the provincial governments, which have much smaller computer requirements than the federal government, there has been a trend toward centralizing the service bureau facilities in order to achieve economies of scale. Saskatchewan operates a centralized facility as does Newfoundland, and there has been a recent consolidation of services in the other Maritime Provinces. In Ontario and Quebec, the largest and most populous provinces, the services are too diverse to permit consolidation into single installations. In response to criticism that the Province of Ontario

government has no rationale for different facilities, and little coordination among them, steps have been undertaken to correct this.(11)

University computing facilities are quasi-government in that their support comes wholly from government provided funds. In Canada NRC, the National Research Council of Canada, has played the role that the National Science Foundation undertook with regard to support of computing facilities in the U.S.A. Even though there is no direct support of university education by the federal government in Canada, NRC does support university research. Direct NRC grants to maintain university computing centers through the fifties and sixties were instrumental in establishing university computing centers and departments of computer science throughout the country. In 1974 NRC no longer supports computing centers directly. Instead it allows holders of research grants to pay partial costs of computing, and it has a computer science grants committee which recommends awards for research in the information sciences.

Among the provinces Ontario and Quebec were the first to adopt overall program for support of university computing facilities. The Quebec educational computer network, a star system based on a CDC CYBER 73, is the largest dedicated network in Canada. In Ontario, between 1969 and 1972 grants of about five million dollars per year were earmarked for computer hardware in universities. Since then these funds have been combined with the regular university allotments in accordance with the principle that universities should make their own priorities on how funds are spent. The identification of computer funds was to have been the initial stage of a rationalization of computing facilities, followed by consolidation of individual centers or co-ordination into networks. However, for reasons which are complex, these later stages have been slow to materialize.

Computer/Communications

Because of its size Canada has a special interest in communications. Like other countries, it has also wanted a strong computing industry. These two factors were paramount in establishing the federal Department of Communications and of principal concern in the extended series of studies and reports undertaken by that department. The first study, directed by a group largely within the Department of Communications, called the Telecommision, produced *Instant World*(12), as its main result, supplemented by a series of conference reports on subjects of topical interest including access to information,(16) the wired city (17) and computers and privacy.(18) *Instant World* presents an exceptionally lucid and well written picture of the tele-communication technology and of its importance to Canada. But it and its supporting studies were regarded as merely setting the stage for the following much larger study, conducted by

the Computer/Communications Task Force under the direction of Dr. Hans von Baeyer.

The Task Force divided into many subgroups and it actively solicited views from industry, universities, consumer groups and other government agencies. After two years it produced its recommendations in a two-volume report entitled *Branching Out*.⁽⁵⁾ Although there were thirty-nine recommendations, most of them were so general, such as requesting that telecommunications be recognized as a key activity, that there was some disappointment with the results. The report provided a policy guideline rather than a detailed set of specific proposals perhaps because as became clear from the public debates which both preceded and followed the appearance of the report, either there was no general agreement, or jurisdiction on them lay between the provincial and federal governments. One recommendation which was not taken up was that the government recognize a *focal point* for activity in computer/communications. However, there are too many government departments and organizations with strong, almost central, interests in these technologies, to allow any one department to be given a principal mandate for their development.

The difficulties encountered in trying to come up with specific proposals can also be illustrated by the problem of determining what form if any, government support of private computer industry should take. The computer field is strewn with the wreckage of large multinational companies who have unsuccessfully tried to compete with IBM in marketing main frame computers, and there is general agreement that it would be suicidal to try this. But then what should be done? There already had been in Canada the experience of large governmental grants to established computer companies. Some years ago the Department of Trade and Industry awarded to large grants, amounting to several million dollars to IBM and CDC. The IBM award was to set up an assembly plant in Quebec, to supplement the large assembly and manufacturing plant in Don Mills, (Toronto). The CDC grant helped establish a plant in Mississauga (outside Toronto) intended, I believe, as a production facility for the Cyber computer which never emerged as a fully developed member of the CDC line. The grant to IBM did lead to a plant which created jobs in a geographical region where it was important to do so, and the CDC grant may have produced comparable benefits, but the awards have been criticized. It is difficult to argue that they have helped develop a Canadian-based computer industry.

Also for complex reasons, the market for software products in Canada has not developed the way experts have felt it would. Also there are many other countries where there is an abundance of skills in the mathematical sciences along with good experience in using computers — Denmark, the U.K., Japan, even India, — and there are hopes for a multinational software industry in everyone of these. The result of all this is that it

becomes very difficult to see how a general recommendation favoring support of the computer industry in Canada should be translated into programs. In this regard the computer technology is not different from other modern technologies. It is also difficult to define national programs for satellites, or nuclear power, or transportation systems. There are those who argue that the problems and costs of such general systems demand an international approach — that multinational groupings are necessary to pool resources, share markets and give reasonable hope of success. However, it is necessary to be careful in accepting such arguments without question because they can be equivalent to saying that there is no room for small enterprises, whatever the originality and quality of the enterprise.

Since publication of *Branching Out* there has been a slow but steady attempt by the government to make the recommendations more specific, to sharpen the policies and to initiate actions. In April 1973 the Department of Communications published a formal position statement outlining policy. (6) In certain areas, particularly those concerned with the relations between computer-service firms and the common carriers, some fairly definite principles are enunciated. A general position is taken that the computer services and software industries are to remain largely unregulated and the need to consult with the provinces is emphasized.

Dr. von Baeyer has remained in the government in charge of a multi-department force charged with the task of coordinating the activities on computer/communications throughout the federal government, and there is evidence of a quiet effectiveness in the work there. However, specific programs have not yet been announced. Those not directly in the government hope that there will be positive results to show for the enormous amount of investigation which has been completed.

Networks

In Canada, perhaps even more than in the United States, the two railroads have played a dominant role in the development of the country and in maintaining communications along the twenty-five-hundred-mile long and hundred-mile-wide strip which embraces most of the populated centers. Computer networks could play an equally important role in making the computer/communications technology a productive force in the country. In 1971 the Science Council of Canada issued a report (15) in which it urged the establishment of a national spine. This was to be a computer network which would offer cheap service along the length of the country, and hence provide an alternative to the establishment of a multiplicity of north-south links, between the densely populated centers of Canada and United States, which would otherwise be the natural mode of development. Although the Telecommission and the Computer/Communications Task Force seemed to favour a Canadian network development, no specific network proposals emerged. Following a two year

major study of a proposed network, to link universities,⁽¹⁴⁾ CANUNET, no funds were ever allocated. A major factor for the failure of CANUNET, and of a related Ontario-based program called METANET, was the difficulty of proving that the networks were needed and would be used. The question arises whether many university computer users really need computing facilities not provided locally, and whether there is any mechanism by which those who do want to use computers elsewhere have funds which are not locked in to their own centers. In this regard the slow rate of increase in ARPA traffic, which has been carefully watched, has suggested caution. In any case, it is suggested that if networks have all the advantages claimed for them, the universities should be willing to make the necessary investment.

Especially important in Canada has been the position of the common carriers, particularly Bell Telephone of Canada, that computer networks is *not* a suitable area for government intervention. They argue that networks are best allowed to grow in a competitive environment as the market develops real applications. In fact, there is impressive evidence that the market is developing the right kinds of service at the right pace. Whatever the reasons, the arguments in favor of government supported computer networks have not prevailed to the point where any government supported network has been launched. Many, myself included, believe that university computing centers in Canada are too narrowly based, that the real costs of their service are not measured, and that establishment of university networks would prove beneficial. Funds are still being sought, if not for setting up full networks, at least for promoting interuniversity communication. It is noteworthy that no Canadian university is a member of ARPA, but I am hesitant to say whether this is due to a reluctance to join in activities with the U.S.A. as pointed out earlier, to a belief that a Canadian network will eventually emerge, or simply due to a lack of need or funds for the services available through ARPA. In any case, the problem of whether to promote and participate in networks, either commercially based or university-based, has not been resolved by Canadian government.*

CONCLUSION

Throughout the world computer technology has been the focus of governmental interest. For good reasons, studies and programs for its growth and development are widespread. Few countries have embarked on a more conscious and intense study of computer/communications and related technologies than has Canada and examples of some of those studies have been mentioned here. Although it is not difficult to agree on

* An exception to this is the special-purpose star system educational network in Quebec, mentioned earlier.

general principles and goals, it is enormously difficult to translate these principles into programs which have reasonable expectation of furthering national goals.

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Chapter 2

SHARING CANADIAN EDUCATIONAL COMPUTING RESOURCES

by T.A.J. Keefer

INTRODUCTION

This chapter traces the history of Canadian Federal Government activities in stimulating the sharing of educational computing resources. Three major activities has been involved, and while these were once in parallel, they have now converged under the auspices of the Educational Technology Program.

The first of these activities, which began in 1970, was CANUNET — the CANadian University computer NETwork program. CANUNET was undertaken in two phases: network design and innovation based on using packet switched technology; and subsidy of communications costs.

The second activity consisted of the Canadian Computer/Communications Task Force which produced the report *Branching Out* in 1972. A Federal Government Interdepartmental Committee on Computer /Communications was then established, with a number of Working Groups: Working Group 19 was formed specifically to study CANUNET. With the incorporation of CANUNET into the Educational Technology Program, this Working Group has now been disbanded.

The third activity, whose timing paralleled these, began with an Interdepartmental Committee whose recommendations led to the creation by the Federal Government of the Educational Technology Program. This Program assists federal and provincial authorities by providing plans, information, and advice on educational technology.

Under the Educational Technology Program a number of joint federal-provincial study programs have now been formalized and are under way. One such study program, to encourage computer resource sharing at the post-secondary level, has recently been developed jointly by the Federal Government and the four Atlantic Provinces.

CANUNET HISTORY

The first initiative of the Canadian Federal Government to stimulate educational computer resource sharing was CANUNET, the CANadian University computer NETwork program. Following an EDUCOM survey of American and Canadian universities in 1970 regarding their possible interest in joining ARPANET, the Department of Communications (DOC) was urged to establish a Canadian university computer network, so that Canadian universities could develop the necessary expertise and experience in this new and important field. Under the leadership of Dr. John de Mercado, a number of studies were carried out to design a suitable packet switched network to interconnect computer facilities of Canadian universities through a national network which would be flexible and transparent to users. (1,3,7)

Following these network design studies, a new approach to CANUNET began to emerge in 1973 when it became apparent that a viable design for a store and forward packet switched network had evolved from ARPANET. Advocates of the new approach considered possible forms of federal funding of inter-university communications costs, to stimulate computer resource sharing at the university level.(2) Under this approach, CANUNET would be realized in two steps: the first would encourage computer resource sharing by alleviating the communications cost component, while the second would be a long range program.

INTERDEPARTMENTAL COMMITTEE ON COMPUTER/COMMUNICATIONS

While CANUNET studies were taking place, the Federal Government had established the Canadian Computer/Communications Task Force in 1970 to provide advice on policy matters in the rapidly evolving field of computer communications. The work of the Task Force, led by Dr. Hans von Baeyer, culminated in its publication of the report *Branching Out* (4) in 1972.

On the basis of the Task Forces's recommendations, the Federal Government then established an Interdepartmental Committee on Computer/Communications which in turn set up a number of Working Groups. In particular, Working Group 19 was formed to examine policy and other matters related to the CANUNET program.

EDUCATIONAL TECHNOLOGY PROGRAM

In parallel with these activities, the Federal Government had established an Interdepartmental Committee on Educational Broadcasting in 1969 to prepare recommendations on what steps should be taken to ensure that technology used in support of education would be cost-beneficial and in the national interest. This Committee's report documented the rising costs of education, the problems and opportunities presented by new electronic technologies, the growing disparities in the capability of different regions to take advantage of these technologies, and the need for educators and technological specialists to work together to ensure that these technologies are effectively employed.

On the basis of this Committee's recommendations, the Federal Government approved the Educational Technology Program in 1972. The Program was subsequently endorsed by the Council of Provincial Ministers of Education.

The Educational Technology Program, managed by the DOC's Educational Technology Branch and led by Dr. John de Mercado, is designed to assist federal and provincial authorities by providing plans, information and advice on educational technology.(6) The Program is also concerned with the development of national standards, and with ensuring that Canadian needs for educational technology can be met where possible by Canadian industry. Operations of the Educational Technology Program can be categorized into four activity areas: federal-provincial programs, inter-departmental programs, national development programs, and liaison activities. Under the first area come a number of joint federal-provincial study programs.

- *Educational Technology Program for Nova Scotia*, with the aim of developing a long term plan to enhance the educational process in Nova Scotia through the cost-effective application of educational technology.(5)
- *Program for the Sharing of Computer Resources in the Atlantic Universities*, with the aim of encouraging the most effective use of present and potential computer resources available to the Atlantic universities and other post-secondary institutions.(8)
- *Program to Study Educational Computing in Newfoundland*, with the aim of studying the current usage and future potential of educational computing in Newfoundland, as an input to the Newfoundland Task Force on Computers and Computer Communications.(9)

National development programs are also underway in the number of other areas such as information dissemination, standardization, testing, evaluation, industrial development, and computer aided learning.

Because the Educational Technology Program is the vehicle by which the Federal Government deals with the Provinces on all matters related to

educational technology, it is logical for CANUNET activities to be handled through the appropriate mechanisms developed between the Federal and Provincial Governments. It was therefore decided, in July 1974, to incorporate all CANUNET activities within the Educational Technology Program. Since Federal Government activities concerned with computer resource sharing at the university level are now included within the Educational Technology Program, CANUNET no longer exists as a separate program, and the CANUNET Working Group 19 has been disbanded.

SHARING COMPUTER RESOURCES IN THE ATLANTIC UNIVERSITIES

One CANUNET-type activity within the Educational Technology Program is the recently initiated Program for the Sharing of Computer Resources in the Atlantic Universities, a joint study to encourage the most effective use of computer resources available to the Atlantic universities and other post-secondary institutions. This joint program involves the Federal Government, the Governments of New Brunswick, Newfoundland, Nova Scotia and Prince Edward Island, the Maritime Provinces Higher Education Commission, and the Association of Atlantic Universities.

The Initial Phase in this program is intended to collect information on needs for and usage of computing resources by the Atlantic universities and other post-secondary institutions, and to study ways of expanding or improving this usage. This phase will: identify existing resources, determine actual and potential for shared use of computers with other educational institutions, with government, and with industry; consider alternate forms of regional cooperation; and study the costs of potential benefits associated with each. Results of the study phase will serve as a basis for recommendations and possible decision concerning the disposition of subsequent phases.

The second phase, if approved, would involve implementation of improvements which could be accomplished without a major increase in resources, and which would not conflict with eventual major developments at the regional level. Such major developments would be planned during the third phase. Following the approval of plans the participating institutions and agencies would prepare resources for implementation of any major regional plan approved, and proceed with implementation.

CONCLUSION

Recognizing the important role that technology will play in education, the Federal Government has established the Educational Technology Program to encourage the most effective utilization of technology in meeting educational needs, thereby ensuring that the maximum benefits

of this technology are received by all Canadians. The success that this Program is enjoying at the federal and provincial levels underlines its timeliness and the importance that all concerned attach to it.

In the area of educational computer resource sharing, the Federal Government is aware that there may be considerable diversity among the Provinces in terms of their needs, resources, priorities and stages of development. Each Province is thus being approached to determine to what extent it wishes to work jointly with the Federal Government in this or an other area of educational technology.

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Chapter 3

PROCESS FOR DEVELOPING RESOURCE SHARING AMONG AUTONOMOUS INSTITUTIONS

by Peter P.M. Meincke

At a recent colloquium on the Future of Scientific Communications sponsored by the National Science Foundation, several speakers, Russell Ackoff in particular, stressed the need to identify and agree upon long range global objectives before dealing with secondary objectives and implementation. He pointed out that it was possible that an overall objective might be attainable together with sub-objectives each of which was, on its own, totally unthinkable. He gave as an example, the following sub-objectives:

- That the capital of France be moved from Paris.
- That Paris become a free city with no passports required or import duties, etc.
- That the French language no longer be the official language of Paris.

Apparently these seemingly impossible objectives are under serious consideration by the government of France. How this is possible only becomes clear when one learns that the long range global objective is to make Paris the informal capital of the world.

When the Task Force on Computer Services began its work, in late 1973, one of the first questions it decided to tackle was to specify long range global objectives. Its terms of reference interestingly enough did not include this task. In fact some of the members, including myself, thought that we would automatically assume that resource sharing was worthwhile and that all we had to do was find an administrative structure to manage

university computing resources which would be acceptable to all Ontario universities.

The Task Force was formed as a result of a proposal to develop a message switched network to join a number of university computer centers, in the Province of Ontario. The objective of the METANET proposal was to facilitate the sharing of computer services among Ontario universities. Objections were raised on a number of grounds. It was not clear that inter-institutional traffic would justify such a network and that existing private communications facilities provided an adequate vehicle. When a consultant pointed out the need to solve the administrative barriers to resource sharing and recommended the formation of the present Task Force, the Task Force was set up by the Board for Computer Coordination of the Council of Ontario Universities. Table 1 lists Task Force members and observers.

Table 1
Task Force on Computer Services

MEMBERS

Dr. H.S. Gellman	President; Gellman, Hayward & Partners Ltd.
Dr. A.J. Grindlay	- Professor, School of Business Administration; The University of Western Ontario.
Mr. W.H. Jenkins	- Director, Computer Centre; Queen's University.
Mr. D.S. Macey	- Office of Computer Coordination; Council of Ontario Universities.
Dr. P.P.M. Meincke	- Vice-Provost; The University of Toronto. (Chairman of Task Force)

OBSERVERS

Dr. G.D. Anderson	- (Chairman of the Board for Computer Co- ordination of the Council of Ontario Univer- sities) Professor, Department of Clinical Epi- demiology and Biostatistics; McMaster Uni- versity.
Mr. H.H. Waiker	- Representative; Committee on University Affairs.

After preliminary discussions, Task Force members concluded that the long range global objective was to make available to the universities computer services which were of the highest quality, effectiveness and efficiency. Certainly few could quarrel with that as a global objective, especially in the face of increasing financial stringencies. The problems come when one explores the sub-objectives that appear to be necessary.

A key question which has to be answered before much progress can be made toward meeting the objective is where should control over computer services lie? One could envisage a province wide educational computing agency funded directly by the Government which would provide free services to all educational institutions. However, this would contravene the standard funding arrangement whereby funds flow to the institutions based entirely on the number of students. It is strictly up to the universities to decide how to spend that money. Moreover, the Government would then be faced with exactly the same problem with which the universities are faced to-day. How can they be sure that the level of service is appropriate and that the service is not being misused? The Task Force endorsed the approach recommended by an earlier COU Task Force on Computer Charging; namely, to put the money to purchase computer services as close to the user as possible. This approach has a number of advantages:

- *The level of service is determined automatically by the aggregate of the decisions of a large number of users and is made in competition with other demands on the dollar at a level where such decisions can best be made.*
- *Decisions about what services should be offered can be made in terms of the viability of those services.* Individual needs could be met by purchasing outside the institution.
- *The effectiveness and efficiency of the facility is much easier to measure in terms of profit or loss.*
- *The cost and benefit of the use of the computer in instruction is assessed where it can best be assessed — close to the instructional process.*
- *The computer center director becomes an entrepreneur.* He or she must be highly conscious of the market and very service oriented; but, is freed from the shackles of special interest user groups and policy committees.

Decisions to put money in the hands of the users of university facilities represent a major change in the mode of management of universities from the traditional mode to a free market mode.

The pattern of management evident in many Ontario colleges and universities in 1974 can be represented schematically as shown in Figure 1. Money flows through some central allocation process in which budget committees, administrators and governing bodies are all involved. It is allocated to the teaching departments and to the facilities such as the computer center, the library and the media center. The nature of the facility and the level of its budget are to some extent determined through the formal mechanism of advisory committees. Attempts are made to measure the quality, efficiency and effectiveness of the service; but, these are very difficult to measure, and the effect on the educational process is even harder to evaluate. By and large, the facility manager is expected to

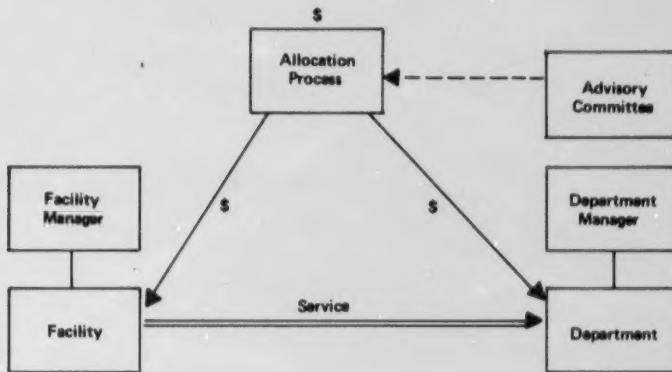


Figure 1. Patterns of Management in Ontario Universities

manage the facility, provide the best service possible within the budget allocation and keep the complaints to a minimum.

Under this mode, the facility is available, the user generally does not have to worry about direct trade offs against other needs and the incentive for the user to control the use of the facility is low. If the facility does not provide adequate service, there are a number of routes for complaints. Usually the facility manager comes under fire first, but it is also possible for the more powerful users to put pressure on deans, central administrators and the advisory committees. If the problem is very serious often an ad hoc task force is formed to examine the situation and make recommendations. This traditional mode of management and has been called the squeaky wheel or paternalistic mode of management. In this mode, it is up to the facilities manager to provide the proper level of service and to fight for adequate funds in competition with the departments, but with the help of the advisory committee. This mode of management is quite successful if funds are not in short supply; but, the facility manager is placed in a very difficult position if the resources are simply not sufficient to meet demand, and no constraints are placed on the source of the demand.

The free market mode is illustrated in Figure 2. The budget allocations are made on the basis of demonstrated need. This requires that the central structures look very carefully at the quality of the research and teaching of the departments and the effectiveness and efficiency with which they use the budget allocation. The departments must decide how they are going to spend the budget allocation and must make hard trade off decisions between buying such things as computer services equipment or supplies. At the departmental level the real value of these services can best be

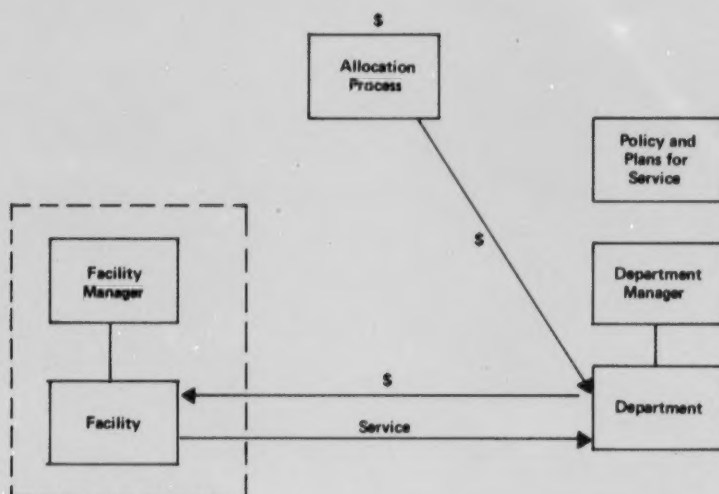


Figure 2. A Free Market Mode of Management for Ontario Universities

judged, but members of the department must accept the authority and responsibility for making such trade off decisions. Real dollars are budgeted for purchasing services from the facility thus establishing the budget of the facility and the level of service to be provided.

Obviously a few caveats are required. If the service is new or if the transaction cost is so small that it is not worth the accounting cost, university policy may provide a more centralized flow of dollars. It would also be necessary to provide for funds to cushion rapid declines in demand and possibly venture capital for new services. A major concern is the effect on the academic environment. The devolution of this real responsibility and authority to the users may create unwanted burdens on the staff. There are already some signs of this in the University of Toronto as the institution moves toward a policy of putting money in the hands of the users.

If universities really did go into a free market mode, whereby users were free to buy computer services wherever they felt they got the best deal and computer center directors were able to make arrangements among themselves to distribute the computing load in the best possible way, then the objective of resource sharing might be met. Certainly the Task Force felt that an essential sub-objective was to put free funds in the hands of the user no matter what else was done.

The shift from one mode to another is a very complex operation. Another possible problem might be unfair competition like selling a computer services at well below cost from facilities with excess capacity. It

was considered essential by the Task Force to have an independent body that a university could call on for advice as money was gradually put in the hands of the user over a period of time. It was also essential to ensure that the prices charged for inter-institutional trade were fair and equitable. Price regulation may seem contrary to the philosophy of a free market, but one has to recognize that universities are not accustomed to inter-institutional trade and there will inevitably be some difficulties in moving into that mode. Thus the Task Force recommended the establishment of a Prices Review Panel. (Figure 3.)

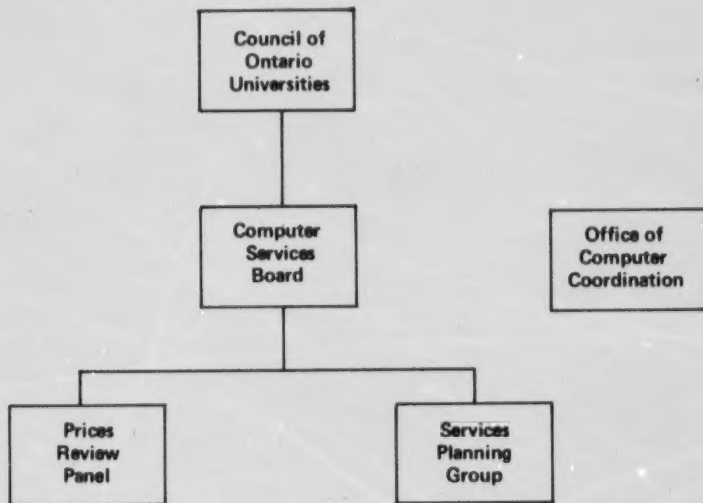


Figure 3. Relationship of Proposed Groups to COU

The Task Force was not convinced that putting money in the hands of the user and expecting the computer center directors to make the necessary arrangements among themselves for the distribution of the load among the facilities would be sufficient to meet the overall long range objective. One must recognize the political realities of the computer center directors situation. Because facilities are still closely linked with universities, any load sharing arrangements suggested by a director would still have to be ratified by the decision making process of each university and be subjected to the same sort of scrutiny that most resource sharing proposals receive.

THE IMPORTANCE OF PROCESS

Sharing of hardware resources in Ontario is rapidly becoming a small part of the much larger picture of computer resource sharing. Software, Data Banks, Catalogue Support Systems, Student Information Systems

are other such computer related resources. Moreover, the whole picture changes very rapidly from year to year. The Task Force felt quite strongly that to recommend a structure for the management of hardware and operating system software alone was to tackle only part of a much larger problem. The group therefore decided to recommend a process rather than a structure.

Ackoff has strongly urged that colleges stop trying to find the Utopian ideal to solve all problems and adopt the notion of process. A process approach, he claims, stimulates creativity because it removes many of the constraints. The Task Force on Computer Sources quite independently came to the conclusion that it had to recommend a process rather than structure in order to cope with the rapidly changing world of computer services and remove some of the self imposed constraints that people develop.

In development of successful resource sharing agreements, the following things have to happen:

- Each institution must clearly articulate exactly what it expects from the service and identify the need for such services.
- Identification of areas where a resource sharing agreement is beneficial in meeting the aggregated needs of some institutions.
- There must be some incentive for the institutions to explore resource sharing possibilities.
- A detailed proposal must be developed so that each institution can assess the effect of the proposal on its capability of meeting the institution's needs.
- There should be an independent review and assessment of the effectiveness of the process.

In addition to these particular activities, there are certain principles which should guide the way in which the process is carried out:

- The institutions themselves must participate directly in the development of the detailed proposals which may affect them.
- It is better to start a sharing project with just a few institutions and then let others join this nucleus.
- Nothing in the process should limit participation to universities alone.
- The management of a resource sharing agreement should rest with the participating institutions.
- It is essential to provide some start-up funds.
- Each institution must retain control over how much and what types of computer services it uses. (This does not mean that the services have to be provided by facilities located at that institution.)
- The most effective implementation of any cooperative project will likely involve some loss of direct control of the facility and will likely mean that money will pass between institutions.

The next question is what is required to make these things happen.

Planning

Originally, the Task Force called the first activity, "Planning for Computer Services instead of Computers". Quite properly, the computer center directors have taken exception to the implication that they have not been planning properly. The Task Force was really calling attention to the fact that many universities operating under current management modes were not clearly articulating what they wanted computing centers to do. Many computer center directors have commented that the universities are only now providing a framework of objectives within which they can operate. Certainly there have been implicit objectives but these have been clearly and publicly stated in very few cases.

It is essential that each university have a reasonably clear idea of what computer services it expects before it can make a sensible decision between alternative methods of providing those services. Although the computer center director may be one of the most qualified individuals to provide such information, he is in a good position politically. An individual outside the direct administrative structure of the computer center can best provide an independent planning for services function. Obviously such an individual is needed if there is no on-campus facility.

Together with his or her counterparts from other universities, the Computer Services Co-ordinator brings together information which would help to identify areas where resource sharing might prove beneficial. The people actually involved should participate in this identification process: the computer center directors in facilities management; the admissions officers for admissions projects; and so on. The Task Force had no intention of eliminating initiatives from these areas but rather facilitating such initiatives. A Services Planning Group composed of all the Computer Services Co-ordinators could facilitate planning for computer services.

Evaluation

Why must there be an independent review and assessment of the effectiveness of the process and how can this best be done? While an ideal systems design should be self-evaluating the credibility of the process is best communicated external agencies such as the Government and even private enterprise through third party evaluation. The Task Force therefore recommended a Computer Services Board to review, evaluate and comment on the detailed project proposals and the reasons given by the universities for not participating. The Board would draw members from both within and outside the universities, and the chairman would be from outside the university community. Evaluative reports would be made public.

An external review and assessment is also essential to counterbalance the pressure from within the universities, which will inevitably come up quite

naturally from users who are vitally concerned about the effect of any resource sharing agreement on their access to, and use of a computing facility. Such pressure in itself is not bad. Concerned users should be concerned if the university is going to down-grade the service to them. However, decisions made with only one side of the picture presented to the decision making bodies of the universities are bound to be one-sided whether proposals are initiated outside the universities, by computer center directors, or by business and admissions officers within the universities. The original proposal for regional centers arose in 1969 from a committee composed of computing center directors. Yet, it is not reasonable to expect the universities to make rational decisions without all sides of the the argument clearly presented. Only a body such as the Computer Services Board can ensure that all sides of the case are presented, and can insist that the decisions on resource sharing continue to rest with the autonomous institutions and yet maintain credibility.

Incentive

The next question is how to provide an incentive for the institutions to explore the opportunities for sharing. Obviously, start-up funds and Government policies play a big role.

The Task Force recommended a phased approach to lower the threshold for participation. In Phase One opportunities for possible resource sharing are identified by initiative anywhere in the system. Institutions should be made aware of opportunities, and those institutions which are interested enough to commit resources to a detailed study opt-in to Phase Two.

In Phase Two a Project Task Force is formed with representatives from only those institutions which have opted-in to this phase. The Project Team develops a detailed proposal which contains estimates of cost/benefit, administrative arrangements and an implementation schedule which is then submitted to the decision making apparatus of the universities and to the Computer Services Board. The universities then decide whether to opt-in to Phase Three. The Board reviews the detailed proposal and the reasons for the decisions of the universities. It makes its own comments and recommendations on these matters.

In Phase Three, implementation of the recommendations of the detailed proposal developed by the Project Task Force, the management of the resource sharing projects or agreements rests with the participating institutions. This is essential if there is to be resource sharing with institutions outside the COU and if the Board itself is to carry out independent review and assessments. Judgments of the Board will not be credible if it is forced to associate itself or the Office of Computer Coordination closely with the management of the projects. The Board will also recommend to the COU on applications for special start-up funds or other grants, and all proposals for major new systems costing in excess of

\$100,000 go to the Board for information, evaluation and recommendation.

The facilitating structure developed by the Task Force is shown in Figure 3. It is the opinion of the Task Force that the recommendations provide for:

- *computer services policy definition* and identification of needs at both the institutional and system level
- *a means of problem perception* by analysis of appropriate information
- *an incentive for institutions* to get together to resolve perceived problems where appropriate
- *a mechanism for participatory development* of detailed proposals and establishment of resource sharing agreements
- *a means of review and assessment* to ensure progress and effectiveness
- *an environment which encourages initiative*
- *a lower threshold for participation*
- *a mechanism for ensuring fair and equitable interinstitutional trade*

WIDER APPLICATIONS

It is very tempting to explore the notion of extending the pattern of the recommendations of the Task Force on Computer Services to cover other information resources. The Library, Computer Centre and the Media Centre of the University of Toronto face very similar problems. Questions of centralization versus decentralization, charging, cost allocation and particularly resource sharing, are common to all three. Certainly, the three services vary considerably in the technical problems and the users they serve, but many of the overall policy matters and problems are extraordinarily alike.

If the detailed management of cooperative projects should not rest with the coordinating structure but rather with the participating institutions then broad policy matters of information resources sharing and the initiation of cooperative projects could be dealt with by a single Review Board, Prices Review Panel and Planning Group.

Chapter 4

DATA BASES AND LIBRARIES

by L.G. Côté

THE PROPOSITION

Despite the title, "Data Bases and Libraries," this paper considers networking for information science, rather than networking for libraries alone. While libraries might constitute a very important part of any information services network, the development and implementation of a National Network of Scientific and Technical Information Services should be based on a model which is eccentric to libraries and not heliocentric.

Information is available broadly, in two ways:

- As published material, refereed and non-refereed, held largely but not exclusively in repositories such as libraries, archives and other document services.
- From the knowledge and experience of scientists, engineers and affiliated practitioners who are also more conversant and more able than librarians to judge the applicability, the quality and relevance of the published material in their respective fields.

Both of these potential resources must be mustered for the operation of a national network and the network model must embrace the latter resource to an extent where the model will not be heliocentric in respect to libraries.

DATA BASES

Calvin N. Mooers of Rockford Research Institute Inc., in Cambridge expresses considerable aggrievement concerning the sad fate of a well-known neologism "descriptor" for which he was the originator. He says that, "We were never able to save the new term from the uttermost semantic corruption which is now its present state". Further, he says, "The latest fate of the term is that it has been taken over by that nonliterate horde of computer scientists who, not knowing that descriptor is not a long-established word listed in the dictionary, are using it promiscuously and erroneously in their prose descriptions of programming methods".

Perhaps the terrible computer scientists, having conscience, have offered retribution by providing the neologism "data base". Calvin Mooers may have dealt with this, but outside of the peers of the privy colleges of computer and information specialists data base is a neologism which is abstruse and nearly inexplorable.

For the record, the National Research Council uses the following explanation: Data base is a computer term which is generally a synonym for file. A file can be: a list of tabulated numerical data; an inventory or listing of the contents of a warehouse (the books and journals of a library or a catalogue); sets of indices of journal articles; sets of abstracts of journal articles; lists of books and articles about a particular subject, a bibliography; statistical data on energy consumption; numerical, geographical and chemical data of fresh water resources; construction or engineering information and data; an inventory of research projects in an institution and similarly on a national basis; or an inventory of skills which support research projects, engineering projects or any other technical endeavor. One might even classify a library's collection of graphic material as a data base.

The factor about a data base which is important, is that the compilation of a data base requires the active participation of experts on the subject of the data base. Further, the on-going updating and operation of a data base information system requires the continuing participation of subject matter experts. Because of this factor — it seems improbable or impractical for a library to extend its operations beyond certain classic boundaries. If this extension is attempted one has something quite different than a library.

LIBRARIES

According to one definition, "A library is a collection of graphic materials, such as books, films, magazines, manuscripts, and phonograph records, designed for use". The extent of these varied graphic materials is limitless, yet librarians are expected to furnish promptly any publication or other record which a patron may desire. Not every demand can be met,

but librarians undertake to meet as many requests as possible. This is done by bringing together the materials of most interest to the users of a library and by listing and arranging them in a fashion which will facilitate the rapid location of a particular work. The modern librarian also endeavors to furnish bits of information from materials in his collection, because library users ordinarily cannot do this for themselves. The duties of individual librarians differ in relation to many factors, such as the objectives, size and location of their institutions; but the work of all can be considered conveniently under the headings of acquisitions, processing (including cataloging and classification), circulation, and reference.

John Stuart Mill, an English philosopher and economist who died in 1873 said: "That so few now dare to be eccentric marks the chief danger of the time." That so few now dare to stick their necks out, now dare to advance an unpopular idea, now dare to express themselves openly when there is a possibility they will be ridiculed marks the chief danger also of our time. Nevertheless, this paper presents a new, potentially unpopular, idea.

The real work of the librarian and the library is one of materials management — that is, the gathering and storing of published information for ready access upon demand, *when identified by other means*. It is an essential foundation activity in the total information field, and should be done as effectively and efficiently as possible. But the sharp point of progress in the information field is in the hands of others: the information specialist, the computer and systems specialists and the subject matter experts. Progress will only be slowed by insisting that this work remain under the control of libraries.

The proposed definition of library clearly supports this view. The main activities of a library are purchasing, inventory control, issue and receipt and cataloguing and classification. All of this is materials management. The one element that is an extension, is that of reference. The work of reference is made monumentally difficult not by the accretion of information but, rather by the accretion of graphic materials. It is now quite improbable that the management and operators of a library can ever get to achieve the intimate knowledge of the subject matter expert of the kind, quality and value of the information contained in their collections of graphic materials.

Compare two catalogue records reproduced in Appendices A and B. One is a library catalogue record made in accordance with current, modern bibliographic standards. The other is a catalogue record of a device that is stocked in one of the material warehouses of the National Research Council. (See Appendices D and E). Look for one characteristic in each of these records. That is, how informative is each record? Incidentally, the science fiction book *A Canticle for Leibowitz* is an allegory which is entertaining, and also gives a very unusual view of a library and librarians.

With more and more published material becoming available each year, on

almost every subject, the provision of a mechanism for finding the *specific* information contents of each book, article, report, etc. is of paramount importance. The content analysis as performed by libraries in their cataloguing operations is relatively lacking in detail. Reference librarians are very adept at using the catalogue to the limit possible, but the limit remains none-the-less. The abstracting and indexing activities of the documentalists is much better as to specific detail, and when combined with the power of the computer to seek out unique combinations of terms, provides a very substantial improvement in the ability to identify rapidly and precisely, the fewest published items most likely to satisfy a given requirement. For good results, an information specialist who is familiar with the different approaches of various groups of documentalists which perform the abstracting and indexing for world-wide use, is required. Best of all is the specific recommendation of an information analysis centre or a subject matter expert, who, being thoroughly familiar with the literature and state of knowledge in a particular field, can enter into a discussion with the user to discern the real nature of his or her information need and level of comprehension and, if necessary, can assist the user in the interpretation of the published information, *or provide the required information from personal experience.*

The inventory of printed matter is ever expanding. No matter the size and tidiness of this hoard, retrieval seldom provides *solutions*. Facts, often trivia, are retrievable but are merely an input to the synergistic methods of problem analysis and solution. The reader is referred to the June 1974 issue (Vol. 30, No. 2) of the *Journal of Documentation* containing a set of Essays to Robert A. Fairthorne. These essays can all be read in a few hours, but, more important, the authors are among the privy council of peers of all facets of the library business.

THE INFORMATION INDUSTRY

Mention of the information industry is important as an early-alerting or an aide-memoire. Three points are sufficient: copyright, author lending fees and the adoption of new technology for the publishing process. The first two points will obviously have at least an economic repercussion on library operations and it is not improbable that systems such as lending and copying will be severely dislocated.

The last point may probably pose the greatest upset to the forward planning of library systems. It is not beyond reason that with the use of new automated techniques and very low cost storage methods, publishers could move squarely into the library and information domain. Further, since publishing is a for-profit industry operation, one might expect quality control and value analysis to a degree not yet achieved by libraries. Comments on this possibility will no doubt be included in a U.S. National Science Foundation commissioned planning guide *INNOVATION in the Dissemination of Scientific and Technical Information.*

CANADA IN THE NORTH AMERICAN PERSPECTIVE

Through a combined process of osmosis principally from the U.S.A. and overt Canadian activity and examination there is a range of strong pressures for Canada to develop a strong and emergent system of scientific and technical information services which are carefully matched to the demonstrable needs of all Canadians.

For the present, the current Canadian course is founded on four watershed items:

- *The study and report by the Science Council of Canada* including Science Council Special Study No. 8 (the Tyas Study) and Science Council Report No. 6 (the Katz Report)
- *The Cabinet instruction of December 1969* to the National Research Council to develop, in concert with existing information organizations, a national STI system. This was to be done under the general direction of the Advisory Board.
- *The National Library Act of 1969*
- *The telecommunication studies* of the Federal Department of Communications, particularly the Von Bayer study of computer-communications, *Branching Out*.

The National Research Council formed the national Advisory Board on Scientific and Technical Information in 1970. It was provided with a full time Executive Secretariat and a Network Planning and Development Staff. Simultaneously, the National Research Council's National Science Library and Technical Information Service undertook a program, jointly with the National Research Council Computation Centre, to develop a range of computer based information services. These services are operated in 1974 as national services from coast to coast.

The National Library, during this period, set about to develop numerous standards, processes and procedures for the federal library system, many of which other Canadian libraries will hopefully follow. Plans for extensive use of computers to provide library support and house-keeping services have also been developed and the first phases of these standards and plans have either been implemented or are just being implemented. Additionally, a large number of activities to provide new information services are underway in the universities, in various departments of federal and provincial governments and in the Canadian information industry (particularly by the publisher).

Some people view this unorchestrated range of activities with dismay. Others, including the author, believe that these individual initiatives are necessary and fruitful. First, most of these activities are undertaken to meet quite well specified and pronounced needs. Therefore, in aggregate they form a firm base for what might be the eventual total Canadian system. Second, the work that is done in this way creates a very much needed increase in depth and variety of Canadian expertise and experts.

The latest development was the inauguration of the Canada Institute for Scientific and Technical Information on 16 October 1974 on the combined resources of two major NRC information services, the National Science Library and the Technical Information Service. The Institute has been provided with a new 14.8 million dollar building which is located within the NRC laboratory complex in Ottawa. The Institute will continue to provide all of the previous services of the founding agencies and will:

- *undertake and assess R & D* for the development of new scientific and technical information (STI) systems and services
- *provide additional national STI Services* which should be operated on a centralized basis because of cost effectiveness or other reasons
- *provide an organization* capable of linking the Canadian Network of STI Services to foreign and international STI networks

There is no question that the work of building a national network of STI Services is still at the organizational and preparatory stage. To date, Institute staff have determined that it is much more prudent to encourage the growth of a variety of relatively small independent systems or networks rather than attempt to establish a working, fully integrated network or system.

Also, national priorities are in a state of rapid evolution. The all-consuming drive for new knowledge to feed research and development and high technology may be waning. The containment of world population and the issues of urbanization, the quality of life, the environment, the world food bank seem to be supplanting the need for ever-increasing technological advances. This environment of shifting sands causes many difficulties in setting goals and objectives for information systems design.

The current planning challenge is that the existing information resources and services required for the Canadian network are owned and managed by a variety of jurisdictions and are not easily shared, nor even known, beyond jurisdictional and institutional boundaries. Further, these resources are clustered in only a few geographical areas and have an extreme heterogeneity of economic, technical and operations practices.

Although staff are faced with these realities, a plan has been proposed and accepted in principle for the development of a network of information referral service offices. It is proposed that existing sources of STI Services such as libraries, document centers, data banks and centers of expertise in the federal, provincial and private sectors will be linked to information users by a referral service network. The network, by maintaining an inventory of all available STI sources and services, will direct a user, no matter *where located in Canada*, to the source or service most appropriate to his or her need. Thus two distinct activities are required:

- *enhancement of existing, and development of new services* as nodes in the network of STI Services by the various departments, agencies, and institutions of all governments, and the private sector, in the areas of their individual missions and expertise in response to demonstrated user needs; and

- *implementation and operation of the referral service network* with its necessary inventories, directories, etc., and personnel to use them, to assist information users to find the right node.

A simple analogy for this service is that of "animated yellow pages." It is a directory service, deeply indexed and classified, to let the client know how or where to get his enquiry answered. It is and will be the linking mechanism or "backbone" network for the national STI system. It will place no limits on the extent of logical or physical subnetworks that may be incorporated into the system.

The NRC is now preparing to implement a pilot operation of this network. One office is to be established in one province. As a co-operative federal/provincial project the network entails the participation of 14 federal government departments and agencies, including the controlled participation of centers of expertise and experts in addition to the provision of documentary and other printed information. It is anticipated that the equivalent kind of provincial resources will also be made available for this pilot operation.

The following objectives have been set for the pilot operation:

- *to evolve a practical model* of the Referral Service Network with field tested operating procedures and standards and the inventories and directories of STI Services and sources currently available
- *to develop procedures* for determining the range and scale of the STI resources and services that will be required to meet the full demonstrable needs of users
- *to examine and project costs* and evolve economic principles for the operation of the Canadian Network of STI Services and
- *to develop the alliances* that will be needed in all levels of government and between the government and private sectors
- *to provide communications* between a client and the referral office at no cost to the client
- *to charge for actual use* of a selected, appropriate information service according to the usual fee of the service
- *to use computer data bases* for directory and index service

The findings and experience as well as the detailed systems design of this venture will be disclosed in future papers.

FINALLY, THE SHERIFF

The pressures, both internal and international, are for governments to take command of the substance of information policy and perhaps even the sum of information services.

The Minister of the Crown to whom the National Research Council reports, spoke recently to a Conference on Mathematics in Canada. Some excerpts, slightly altered, apply also to the information business.

"In his recent book, *The Best and the Brightest*, David Halberstam describes Lyndon B. Johnson's reaction to John F. Kennedy's first Cabinet: 'Stunned by their glamour and intellect, he (Johnson) had rushed back to tell (Sam) Rayburn, his great and crafty mentor, about them, about how brilliant each was, that fellow Bundy from Harvard, Rusk from Rockefeller, McNamara from Ford. On he went, naming them all. "Well, Lyndon, you may be right and they may be every bit as intelligent as you say", said Rayburn, "but I'd feel a whole lot better about them if just one of them had run for sheriff once." ' "

"Thus we have at least these three strands: Information Systems as the artistic creation of imaginary worlds; Information Systems,⁸ as a mysterious supertool to be used by experts to save this world from the bungling bureaucrats and predatory politicians; and information as the intellectual trappings of boy-wonders who have never met a payroll, never run for sheriff, and shouldn't try to run the country. (In this last view, the sheriff, the great man, is independent of analysis, flying on judgement, hunch and the seat of his pants, because no information system can capture his problem.)"

"Our community assigns the responsibility for taking decisions to a collection of action-oriented individuals, people who have run for sheriff — who spend their life running for sheriff — and who are actually aware, in a general manner, of where the country ought to go, but lack the detailed itinerary and the choice of means to go there."

"The point is that you must not assume that only the intellectual force of an argument matters in the process of policy formation. Optimizing models are one thing, but the structures of a bureaucracy and the processes of decision-making have dynamics of their own, and they are not irrelevant in taking decisions. The Rayburn view is a useful antidote to the claims for supertools as the saviours of the system."

"But don't tell me that it's all just a matter of getting the policy-maker to listen, or transplanting existing tools. The problems are hard, hard beyond your students' ability to handle them, beyond the power of your present tools even to phrase the important questions that must be posed. The task will take patience, infinite attention to the detail of institutional structures and the process of policy-making, and a willingness to live with inelegant, approximate, and *ad-hoc* solutions. It also requires a willingness to see your cherished proposals, product of laborious hours, rejected on the judgement of some sheriff who wouldn't know an optimum from an integral."

Chapter 5

TOWARD A FACILITATING NETWORK*

by Joe B. Wyatt

People are already saying that they are tired of hearing about networking. It is not completely clear whether this is a result of the fact that computer networks are technologically passe or whether networks are considered enough of a problem that they rank with inflation, the energy crisis, and other contemporary afflictions. What networks do appear to represent is either pressure for change or opportunity for change depending on one's point of view. For this discussion, networks will be put into the perspective of the educational enterprise. Knowledge is the product, not computer systems or networks.

Each institution in the education enterprise deals with two basic problems about knowledge: the delivery of knowledge called instruction; and the development of new knowledge called research. The preponderance of activity in terms of total dollars expended is in these two areas. The administration of each university which provides the money and the management to hold it together accounts for most of the rest of the effort.

The education enterprise has been increasingly criticized for its inefficiency in delivering knowledge to people. Responding by pointing to the fact that they are required to teach more material in less time, educators also point to their contribution in the development of new

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knowledge. Meanwhile the appetite of people for knowledge continues to increase.

Setting aside the considerations of research and administration one can talk about the manner in which knowledge is delivered to people and, more specifically, about the role that computers and networks might play in that activity. The delivery of knowledge is a function which is clearly pertinent to the development and use of a facilitating network.

It's reasonably certain that the leverage provided by electronic technology in conjunction with printing technology has a significant amount of untapped potential. For example, in the two decades since 1950 the printed material collected by college and university libraries has quadrupled. At that same rate of expansion in two more decades the representation of knowledge in printed form will have multiplied sixteen fold from its 1950 level.(1) At the same time, electronic technology in the form of television is represented in 70,000,000 american homes. Already 11% of these home are connected to cable television, the medium that promises to offer two way communication capability and a marriage with computer technology.(4) In addition, there are over forty licensed instructional television stations in colleges and universities operating exclusively for the delivery of knowledge.(5) Many are undoubtedly familiar with the statistics on the expansion of computer systems in North America. The growth rate is exponential and continues even more encouraged by the introduction of minicomputers and microcomputers.

With all the potential leverage available it can be argued that higher education is not effectively utilizing technological facilities for delivery of educational material. For example, in the last decade costs have averaged an increase of five to seven percent a year excluding 1973-74 where costs have risen even more dramatically. At the same time productivity as measured in students output per man hour has shuffled upward at a rate of 2% a year undercut only by the U.S. Post Office's snails pace of .23% a year. By comparison, the productivity of the communications industry has grown at a rate of about 6.2% a year during the same period.(3) In an analysis of the contribution of electronic technology to education a Carnegie Commission study concluded that it is: 1) coming along more slowly; 2) costing more money; and 3) adding rather than replacing the older approaches.(6) The study also concludes that the use of electronic technology in delivering educational material has substantially trailed other uses in colleges and universities such as research, administration and even the library. There appear to be several reasons for this deficiency.

First, the technology has been oversold for this purpose. At the same time, it is evolving so rapidly that it is unstable for those who attempt to use it. In many cases technologists are changing and developing the computer system at the same time teachers and others are attempting to use it for the development of teaching materials. Moreover, computer systems have been experiencing a major evolution approximately every

three years. For any major development of instructional material taking the form of computer programmed software three years is simply not a sufficient period for design, development, testing and installation in a curriculum of instruction. This mismatch between technological development and the development of instructional material continues to plague the most contemporary of our efforts including PLATO and TICCIT.

Second, it is both difficult and expensive to use technology for the development of instructional material. Special effort is required on the part of the teacher. The course must be re-thought and material must be restructured. Special assistance is required. The teacher must join with a set of strangers in the development of instructional material including computer technologists, television technologists, and a host of related people who have quite different interests and idiosyncrasies from book publishers. This is a strange experience for many teachers and it appears that the technologists may not be enhancing the relationship. For example, Lloyd Morriset indicated that it required one year's time to get the television people and the teaching people sufficiently close together to produce the first pilot of the program Sesame Street.(2)

Third, and probably most pertinent to this discussion, the mobility of material represented by educational technology is substantially less than that represented in the form of books. This is particularly true of large software systems. It simply isn't easy to move a major system from one computer to another even when both computer systems are compatible including hardware and software (IBM 370 165 running OS/VS1 or CDC 6600's running kronos 2.1). The actual manifestations of these systems are sufficiently modified by local installations to make software mobility a significant translation problem which can be addressed only by relatively scarce experts.

Fourth, educational technology has been overly institutionalized. Educational institutions have acquired the paraphernalia of educational technology under the assumption that it would be used by the faculty for good works. In too many cases, the trappings were installed and expectations were appropriately adjusted upward with no specific plans for the development of educational material. As a result, the faculty followed their research interests and the administration availed itself of the efficiency provided by the technology. As the Carnegie Commission report shows, instruction has finished in last place.

Fifth, there is not an adequate way to measure the effectiveness of the use of electronic technology in teaching as compared to traditional media and methods. In fact, the capacity of colleges and universities to measure the effectiveness of teaching as a whole is deficient. The introduction of a new technology into the teaching system simply magnifies that basic problem.

Although the overall picture of the use of educational technology in teaching is pessimistic, one continues to hear of specific successful examples of computer assisted instruction. It appears that in order for technology (particularly computer technology) to be broadly successful there must be developed an effective and efficient mechanism analogous to the book publishing industry for the distribution of technology based teaching material. There is now nothing comparable to the multi-billion dollar book publishing industry for technology based material. Moreover, some large book publishers, after establishing joint ventures with major computer manufacturers several years ago have not yet really focussed on the development of material for the electronic media.

There is substantial possibility that networking might be able to deal with this very fundamental problem. The use of networks to remotely access both software and data appears to present a new opportunity for tackling the distribution problem. In making the point for networking one should not exclude the potential of minicomputers and microcomputers. The optimum contribution of networking to educational technology will be performed in conjunction with minicomputer and microcomputer technology. The fact is, however, that some universities are developing very large and very complex computing resources which will not be duplicated in large numbers around the country. Even the large institutions will not have individual copies of the ILLIAC 4 and the NCAR computer resource. It is also an overwhelming problem to replicate or move some of the large and complex software and data systems. In addition, more often than not the systems cannot be operated reliably or maintained and improved without substantial expense and a lengthy learning curve. Universities are also developing very large and complex data bases which will have to be limited in number.

THE FACILITATING NETWORK

On the basis of this evidence it makes some sense to consider the development of a network to facilitate access to scarce resources by a large number of people scattered across the colleges and universities of North America. Most of the people who will use such systems are not computer scientists, but are ordinary people who wish to treat the computer as a tool and not as a subject. Some of these people are not even using computers now and will need a computer resource that does not have the appearance of an experimental technological apparatus. For these users the relative stability of a book will have to be much more nearly approximated by the local university computer service.

For purposes of this discussion the facilitating network is characterized by two basic ingredients

- a *communications resource* capable of connecting computers to

terminals and computers to other computers over long distances reliably, efficiently, and relatively inexpensively

- *a host of services* that are required to make computer resources useful to a group of geographically and culturally diverse users.

The computer culture of colleges and universities varies substantially and must be dealt with successfully in any such venture. For example, a software system that works handily at Dartmouth might represent a culture shock at Harvard. Services will need to include information about computer resources and programs, instructions on how to use the resources, standards for communication protocols and other interfacing services without which is generated for the ordinary computer user. There would also need to be some means of measuring and accounting for network transactions.

The most pervasive questions about facilitating services relate to the usage of such a facilitating network. The first ingredient, communications facilities, will probably be available from one or more commercial vendors. The second ingredient, facilitating services, represents a set of problems to be solved.

Benefits. Several benefits of networking can be realized relatively soon, perhaps in 1975. First there is the possibility of bilateral arrangements between institutions. If one assumes that a set of computers (and terminals) can be connected to enable multiple users to remotely access a variety of computer resources, then institutions can develop bilateral agreements for purchasing, selling, and exchanging computer and information resources. Some such arrangements already exist like the Harvard-MIT example. Extending the hypothesis, Stanford could buy basic time-sharing service from Dartmouth instead of buying another PDP 10. Dartmouth could buy large-scale numerical processing capability from Princeton. Princeton could buy PLATO services from the University of Illinois. The University of Illinois could buy MULTICS services from MIT. Harvard, which is in the position of being primarily a buyer rather than a seller of services, might buy some of each service from each of these institutions. Such an arrangement of bilateral agreements would be completely extendable to other institutions.

A network also promises much broader access to scarce resources. A large number of computer users can have remote access to computer and information resources that would otherwise be unavailable locally. Already established national and regional centers of computing and computer-based information like ILLIAC 4 and NCAR have already been mentioned. There is also currently a proposal for a National Center for Computation in Chemistry. Two noteworthy examples in the area of library circulation and control are BALLOTS developed at Stanford University and the Ohio College Library Consortium system (OCLC). It is very unlikely that individual universities can afford or should develop a

large number of such systems. Because it is difficult to move such a complex system to numerous different computer systems and because major problems are created in software maintenance and operation, it is natural to consider networks as a means of access to systems of the type characterized by BALLOTS and OCLC for libraries. The proposition extends to data resources as well. Large complex data collections such as the 1970 census, the data collected by the Opinion Research Center, the economic data collected and maintained by the National Bureau of Economic Research and a host of other collections are sufficiently important that they are collected and accurately maintained. They are sufficiently costly that the effort should not be duplicated. They are sufficiently valuable and interesting that they should be accessible by a wide variety of users.

Finally, short-term uses of computer resources would be facilitated by a type of network which would provide means for a user to purchase job lot computer capacity. A variety of motivations can be envisioned for such a service including price and response time. For example, between four computer resources used by Harvard, a collection of jobs which cost \$109,000 to run on one of the facilities alone can be performed by an optimum choice among the four facilities at a cost of approximately \$70,000. The worst case cost would have been approximately \$120,000. The computer systems involved were compatible to the extent that translation of job control languages between the resources could be performed by a programmed algorithm. This range of cost would seem to indicate that substantial dollars could be made available to facilitate network access to multiple resources and still have a remainder of substantial savings in user cost. The acquisition of computer capacity as a price driven commodity is relatively new to university computer users. It appears to be a rather natural phenomena that computer users, given the opportunity, will seek out the maximum computation on the basis of available funds. In this case the facilitating network would serve the role of "making the market" for such transactions. Up to date quotations could be provided on the availability of specific services, the location, the price, the expected response time and other variables of interest.

These three types of service — bilateral long-term arrangements between universities, access to scarce resources by a large number of users and short-term transactions for computer capacity would seem to characterize an immediately useful set of activities for a facilitating network. The ingredients necessary for this type of network not already available will probably be available within a year. With this prospect, it is time now to plan for their use.

Problems to be solved. It may be useful to discuss the most useful next steps toward an initial facilitating network. A first consideration is the communications facilities. Within the coming year (or 1976 at the latest) multiple common carrier facilities designed specifically for computer

communications will be available priced substantially below current rates, and in some cases priced on a distance independent basis. To use one example, Telenet Corporation of Washington, D.C. has promised a seven city network by the middle of 1975. This network will initially connect Boston, New York, Washington, D.C., Chicago, Dallas, San Francisco, and Los Angeles. The network will use packet switching technology derived from the ARPANET and implemented in advanced hardware. Servicing will be priced independently of distance transmitted. By the end of another twelve to eighteen months eleven additional cities will be added to the network. As a result, eighteen major population centers in the United States will be provided with a national communications resource designed for digital computer systems making the communications network accessible to hundreds of colleges and universities. Competitive networks are also in the process of developing initial operation between specific cities with a variety of services. With the availability of such communication networks, bilateral agreements between colleges and universities could begin almost immediately. It therefore appears prudent as one step to begin the facilitating network with a collection of bilateral arrangements between universities. In this way each institution could judge the merits of the services acquired or sold on the basis of the liabilities and benefits which would specifically be a consequence of such an arrangement.

Second, there is the problem of information dissemination or marketing which is required in order to communicate appropriate information about the available services to the potential and active customer market. Such an interface between multiple users and multiple resources is so critical, that development of it cannot be left to chance. The part of the interface activity which involves various types of local user services would likely have the characteristics of a local network which would interface a variety of users to a variety of computer resources via multiple communications networks. Another part is the problem of operating and managing the national network with the associated users-network-resources interfaces. Although it is highly appropriate in the beginning to avoid over management of the facilitating network, some minimal user services, such as providing for marketing, accounting, and measurement of transactions performed in the network, can probably best be performed by some organized group with the appropriate mission and motivations.

Third, there is the problem of user advocacy. In order for a facilitating network to operate successfully there will be a need for a consumer report function. While it does not appear feasible to have a facilitating network organization attempt to certify all of the services offered through the network, neither does it appear appropriate to have no communication about the quality of such services. The development and maintenance of a viable consumer oriented reporting service based on actual user experience (with appropriate tests in addition) would appear to be a useful

alternative. By necessity such a service would need to give frank reports, about the quality of specific services offered via the network. Unless this and other elements of a user advocacy role are developed it seems very likely that the viability of a network will be limited. It could even be sufficiently limited to defeat the purpose of networking to the extent that autonomous and duplicate resources would continue to flourish. There are certainly alternatives to networks currently and more on the horizon via mini and microcomputer technology. Another alternative, of course, is an undesirable situation in which activities simply do not happen because of the lack of availability of either a private resource or a network to facilitate use.

Fourth, there is the problem of inter-institutional cooperation. When one considers the operation of a network on a very large scale involving a large number of institutions and an even larger number of computers and computer users there are a number of additional considerations for the successful operation of a facilitating network. As a result of the size of such a network there will be a requirement for some level of organization in the form of more formalized inter-institutional cooperation. In many cases institutions have considered themselves rather autonomous with regard to specific activities and interests including research, instruction, and even the method by which the institution is managed. Much of this autonomy is steeped in tradition and has endured despite growing pressures. Networking may preserve those which are useful but offer an opportunity to dispense with those that have become liabilities. Since networking is by definition an inter-institutional activity, it must be recognized as such by any effort to develop and operate a facilitating network. It appears that the necessary inter-institutional cooperation will require activity at at least three levels within each participating institution. It will require the computer people to operate the network and provide the local interface to it. It will require enlightened faculty and students to use it. It will require the participation of the administration to recognize its role in institutional development and operation. A small inter-institutional organization, including these types of people, has already been formed. The organization, known as the Planning Council for Computing in Education and Research, has as one of its principle objectives the development of a viable facilitating network of computer resources. Institutions are represented on a Planning Council Policy Board by university executives and on a technical committee by computer scientists, computing center directors and faculty. Dr. James Emery has been hired as the Executive Director for the Planning Council. Each institution has agreed to contribute \$10,000 per year for a minimum three year period to support the basic operation of the Planning Council. Grant funds are being sought to match the institutional contribution. It is envisioned that mission oriented projects would be developed and funded incrementally.

Specific Activities. In addition to the organizational activity, manifested in the Planning Council, several other specific activities appear to be necessary for the development of a facilitating network. One is the need for analysis and evaluation. Too many large-scale efforts associated with computer technology (specifically computer operating systems) have begun and developed with very little planning and analysis with the penalty for many of ineffectiveness and expense. The emphasis of such an activity would not be primarily technological. Rather, the emphasis would be on economic, behavioral, organizational, and political issues which are critical to the successful operation of a facilitating network. The project would have as its primary objective development of a tool which could be used by any institution contemplating participation in networking to evaluate the impact on the institution of participation. With this tool, the effects of balance of trade, alterations in student and faculty behavior relative to computer based instruction, and other consequences of resource sharing could be assessed in a simulated game prior to commitment. For example, one phenomena which might be evaluated is the effect of making a free market of computer resources available to computer users holding purchasing power. A study funded by the National Science Foundation of the feasibility of such an activity has been completed. Subsequently, a proposal has been developed to define and propose funding for a "Network Simulation and Gaming" project which would involve sixteen different institutions ranging in type, size, and geographic location. The project which will be developed in three phases, model design and development, model testing, and gaming, will span three years and cost approximately \$800,000. The ultimate objective of the project is to develop a simulation model and game which could be used by executive officers, computer resource managers, and computer users of each institution in order to assess the effects of joining a computer network.

A second activity necessary for the development of the facilitating network is experimentation. There has been a good deal of experimentation in the technological aspects of networking. One vital experiment which has not been performed is a trial network based on real economic conditions. Such an experimental network might consist of a small number of institutions in geographically diverse locations each having a specific need for some service offered by one or more of the other institutions participating in the experimental network. The critical characteristic of such an experimental network is that it *not* be fully subsidized and that each institution pay at full cost for all computing and communications resources required for operation and use. Unless such an experimental network stands on its own economic feet or fails, it is not likely to demonstrate anymore than the ARPANET has already contributed.

A third activity necessary for the facilitating network will be the development of new types of local user services. There are a number of university computing facilities that don't do an adequate job now of providing services to local computer users. It is a difficult task in which hard decisions have to be made on the allocation of resources. In a distributed network where access to a wide variety of computer resources is performed remotely, it is critical that services be provided to inform users about the availability of multiple computer services and how to use them. Such a local network interface system might give price quotations on the basis of stored use profiles matched against computing resources available about the national network. The system might also provide facilities to translate from one computer-specific language to another in order to facilitate the mobility of jobs and data. (This is a very formidable and counter-productive activity for an ordinary computer user who is not and does not wish to be familiar with the details of computer job control languages). The connection of multiple types of terminals to multiple types of computers will also require some automatic facilitation and translation of communications protocols which might be performed by the network interface system. A number of other user services might also be provided by the system.

Finally, there is the requirement for information dissemination. In one view, a large data base somewhere in the network could respond to users requests for information about the services available in the network. Another and more likely view is that such a facility will be highly institution dependent. In the aggregate, the mass of information required might represent a virtually unmanageable data base. For any individual institution or perhaps even groups of users within institutions, the amount of information required in an active file would be relatively small. If such information is partitioned into smaller more user oriented pieces its access and dissemination might be addressable by the use of minicomputer technology in conjunction with microfilm and microfiche equipment. In this way small computer based information retrieval systems could be combined in a distributed information system to provide for communicating information about the facilities in the network to multiple users. It is this activity, adequate interface between resources and users which appears to be at least as critical as the other three and is probably a necessary condition for the success of any large-scale networking activity.

CONCLUSION

To summarize, the facilities of such a network must be accessible and useful to ordinary people. The network must grant usable access to major computer and information resources which will represent the next generation of computers for a large number of college and university computer users and which would be made available by the facilitating

network as opposed to the local acquisition of computer hardware and software. In some cases of scarce and expensive resources, it is completely impractical to consider acquisition on an individual basis in any case. A facilitating network also seems the most efficient way to distribute the products of large-scale systems development in which the U.S. has so large an investment such as PLATO, BALLOTS, NCAR, ILLIAC 4 and a host of others. The potential benefits to education are paramount. With development of an appropriate facilitating network, new forms of leverage in the delivery of instructional material to students will be available. There is also evidence to indicate that access to more than one computer system can produce a reduction in the cost of computing services. Different computing systems and different pricing algorithms for computing systems combine to produce an environment in which a specific computing task can range in cost very widely depending on the particular resource which is used.

The cost for beginning a trial network on an experimental basis may not be very high. Using a price quotation provided by Telenet Corporation, computer resources and user terminals at seven different institutions located in Massachusetts, Texas, New Jersey, California, Illinois, and New Hampshire can be joined for basic operation at a fixed cost of about \$1,000 a month for each institution. All other costs are variable at a rate of \$.60 per million bits communicated. The latter figures for communication represent truly variable cost to the extent that no transmission implies no charge above the fixed charge. For a good number of the applications previously cited, it appears that communications costs at this level would represent a very attractive alternative. Such an activity does not diminish the importance of a local computer facility. It increases the need for viable and effective user interface to computer systems. In return, such a network will provide access to a new generation of computing services for a larger number of computer users.

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Part II

**Integrating CATV
and Computing
in Instruction**

Chapter 6

ISIS: The Instruction Support Information System

by William F. Luebbert

An Information System is a system that does something with information. It may *process* it as a computer does; it may *store* it as does the integrated data store data base of the West Point Academic Management Information System; it may *communicate* it as a television system does; it may *display* it as the various media of audio-visual instructional technology do; or, it may do a complex combination of these things as computer *graphic systems* often do.

In 1803 the United States Military Academy at West Point introduced to the United States what is perhaps the most widely used and successful item of instructional technology used today, the classroom wall blackboard. Since then West Point has been a persistent innovator in the use of technological aids and tools of instruction support. Out of this tradition, and a decision in 1965 to place its computer and television facilities under common academic management oriented toward educational support, has come the Instruction Support Information System (ISIS).

ISIS is both a concept and a fully operational system which includes as subsystems: a state-of-the-art television cable distribution system; a time-sharing computer system; a significant interactive computer graphics capability; and many of the functional capabilities which have been hypothesized for what is variously called "the wired city" or "the community information utility."

THE TOOL ASPECT OF ISIS

ISIS is a tool-oriented system. The various components of the overall system are organized to provide the student and the instructor with tools they can use as they wish and where they wish in classes, department offices, learning resource centers in individual academic buildings, laboratories, in barracks (dormitories), the library or any place on the campus normally and frequently used as a learning area.

In 1851 Charles Babbage, the father of the computer, wrote:

"It is not a bad definition of *man*
to describe him as a *tool-making animal*"

(Emphasis Babbage's.) Babbage realized that tools from the stone ax to the most advanced technology of his day affect not only what one is physically capable of doing, but one's perceptions of the world, and even how one thinks. Babbage was also one of the first to realize that physical tools are less likely to have a major impact upon human intellectual processes than tools which work on the raw material of human thought, information.

Some informational tools such as the printing press and the modern computer have dramatically affected ease of access to stored human experience. Others like the telephone, radio and television have dramatically affected the ease of passing or sharing information from one person to another or from one person to a large group of persons simultaneously. The term "information system" is often applied to either.

At the end of World War II an information system development of each type burst into public consciousness and began a meteoric rise to the status of a multi-billion dollar industry with direct impact upon the life of every man, woman and child in the United States. The first, television, was a communications tool capable of transferring vast amounts of information from place to place. The second, the computer, was an information storage and manipulative tool capable of transforming information, and of creating interesting and often unexpected results from available information. Each in its own way has had a profound impact upon society. Both are widely used in the educational process, but neither has had the kind nor amount of impact that was originally predicted. Television has not replaced the teacher as primary presenter of information, and the computer used as a controller and presenter of programmed instruction materials has had limited and selective success.

Carefully applied in carefully selected situations both technologies have been pedagogically effective and cost-effective. More often than not they have been flaming failures because educators were asked to mold themselves to the tool rather than the tool to the world. Instead of providing the student and instructor with the information systems equivalent of small and flexible but powerful hand tools and shop tools educational technology has time and again been prescribed as a very

efficient and effective production line which turns out a specialized product.

The Instruction Support Information System philosophically adjoins that approach. Its emphasis is upon the electronic information system equivalent of the electric drill, the sabre saw, and the electric sander. It emphasizes small, discrete capabilities and packages which can be combined freely as needed with the educational technology equivalents of hand tools like blackboards and classroom maps, and it emphasizes making those capabilities freely available where and when needed. Television programs are not forced into any fixed mold. They can be any length (the shorter the better) and shown at any time (or even multiple times within the same period). Primary access to the computer (except perhaps for computer science courses) is via interactive time-share terminals which often support graphic or pictorial rather than tabular output. The instructor and student are provided a full tool kit which they can use to meet their individual requirements.

INFORMATION SYSTEMS OF ISIS

The community information systems proposed by the President's Office of Telecommunications Policy under the catch-all title of "Community Information Utility," or sometimes under the shorter and more evocative name of the "The Wired City," are examples of complex, fully integrated, hypothetical systems built around integrated combinations of computer and television technologies.

One of the most well-publicized examples is the TICCIT system, developed by MITRE Corporation, which incorporated both computer and television technology, in an experimental system at Reston, Virginia. In this experiment, one of the most important aspects is use of the system for educational purposes. Thus, TICCIT is an Instruction Support Information System which supports only a dozen terminals or work stations.

Not long ago, the Department of the Army Study Advisory Group dealing with such systems held a meeting at West Point and unexpectedly realized that ISIS was a perfect example of a large-scale educational information utility with hundreds of terminals already installed and in full operational status.

- Since the mid-1960's, it has been possible for academic computer users to use a computer not just by going to the Computer Center, but by means of a timesharing terminal from any academic building or even cadet barracks.
- Since the mid-1960's, it has also been possible to show a single film or videotape in many classrooms at once.
- Since 1970, it has been possible for a timeshare computer user to keep track of his status on the computer by observing a live

computer-generated television display — identical to that used by the computer console operator to tell him the status of the computer — which is transmitted over the television system to whatever academic building he may be operating his timeshare terminal from.

- Since 1971, it has been possible for an instructor using a computer terminal in his classroom to display its printed output in electronic form on the screen of his classroom television set.
- Since 1972, it has been possible for an instructor using a computer terminal in his classroom to generate pictures, graphs, pie charts and many kinds of line drawings and to display them on the screen of his classroom television set.
- Since 1972, it has been possible for any cadet to go to any of over 100 computer terminals available for his use and make an inquiry about his current grade status in every course in which he is enrolled, or for an instructor who needs information for counseling one or more cadets to get similar information. When it comes to course registration time, the cadet can pre-register from a computer terminal as well, and the computer program will check to make sure that he does not schedule himself into a situation where he fails to take prescribed courses or alternates, or somehow gets himself into the situation where he might not meet graduation requirements.
- Since 1973 a total capability has been available and it is no longer uncommon, for an academic department to make a color television program in which many of the visuals are computer prepared and displayed dynamically and in mathematically accurate and precise form via computer graphics and supplemented by 35mm slides, view-graphs, or even textbook printed graphics produced by the same computer programs.

These are all examples of services that West Point's integrated Instruction Support Information System provides to faculty and cadets.

On the West Point campus, in any academic building or in the cadet barracks, signs announce ISIS Learning Resource Centers. Behind each door so labeled one finds computer terminals, some study carrels with special audio-visual or television equipment, or both. Virtually every classroom and academic laboratory has a color television receiver, and in many of them a timesharing computer outlet going back to the Communications-Electronics Division's electronic switching center located in the Academic Computer Center. Indeed one of the most interesting capabilities of ISIS is the ability it provides for one to go into any classroom which has either a computer outlet or even a conventional telephone readily available, to dial back into the central computer, and to run and control computer programs which produce graphic or pictorial output on the television set in the classroom. Most departments also have computer terminals permanently installed in the office area. From the ISIS Learning Resource Center in an academic building or from the department

office faculty can dial in and request course enrollment and current grade status information on the West Point implementation of ISIS.

ISIS SUBSYSTEMS

The overall system at West Point has several subsystems: the computer subsystem operated by the Academic Computer Center; and the television subsystem operated by the Instructional Technology Center. Computer graphics, which is emphasized very strongly at West Point, is offered by both subsystems.

Other subsystems include: media activities performed by the Instructional Technology Center like the production of educational films or multi-media production; media activities provided by the non-academic Communications-Electronics Division of the Academy; things done by the Photo Laboratory or Training Devices Shop; and the Academic Management Information System which is the responsibility of the Academic Management Information Center.

The faculty member or cadet does not have to understand all the technological or organizational subtleties of the subsystem in order to use it. He goes to a single location known as EASE, the Educational Assistance & Scheduling Element, where he can order production of any kind of educational support from a simple line drawing or viewgraph to the production of a television program, and when he can order any kind of educational support service from the scheduling of an auditorium to the check-out of a portable attache-case-type computer terminal which he can take home and use from his quarters. Within EASE, there are consultants familiar with all aspects of Instruction Support, who will help him to define his problem and to develop an approach for its solution which is both educationally effective and as simple, reliable, and cost-effective as possible.

Computer Subsystems

The computer subsystem is housed in a large quiet, air-conditioned room, in Thayer Hall filled with large blue boxes and usually empty of people. This contains the central processing unit of the Honeywell-635 which is the main academic computer, together with one million characters of internal core memory, drum and disc file storage, and the timesharing communications processors. Next to it is the master control room where the computer operators work. In addition to operators' consoles, it contains tape drives, an upper-lower case high-speed printer and a card punch for supporting conventional batch operations. In the adjacent "mule room" or do-it-yourself batch processing area, cadets and faculty have free access to the card readers and printers to do batch-processing computer runs.

Across the hall is a Learning Resource Center dedicated to support batch

processing activities which is filled with card punches, a sorter, interpreter, and mark sense punch for preparing and handling punch cards. Two other Learning Resource Centers in the same building support the computer in its timeshare mode of operation. One contains primarily teletypewriter-like Terminet 300 printing terminals and timesharing pen-plotters, and the other holds primarily graphics terminals.

A second Academic building, Washington Hall, also has three Learning Resource Centers, two devoted to printing terminals and one to graphics. Two other academic buildings, Mahan and Bartlett Halls, also have their own Learning Resource Centers with mixed printing and graphics capabilities.

Each building of Cadet Barracks has a Learning Resource Center containing a number of terminals, at least equal to the number of cadet companies in that barracks. Most academic departments have at least one printing terminal available to faculty in the department office area, and ten portable "portacom" terminals are available for a cadet or faculty member to check out for use at home or in classrooms.

TV Subsystem

Thayer Hall is also the central home of the television subsystem. The central production facility consists of a studio where most TV production is done containing cameras, lighting sets, microphones, and so on. Next to it is a studio control room, which is the home of the TV director, technical director, video and audio technicians. Next to that is the production equipment room with an editing-qualified professional videotape recorder and other equipment such as motion picture and 35mm slide projectors and pick-up cameras. Nearby is the maintenance area and the television playback area with the cablehead for both networks, playback switcher, film and videotape playback units, and related equipment.

The playback distribution system snakes out into nearly every classroom and laboratory and most departmental office areas of every academic building, as well as a considerable number of additional outlets in the library, barracks, most academic administrative areas, the gymnasium, Cadet Activities Building, and so on. Most of these locations have color television receivers although a few the ISIS computer laboratories, have only black-and-white sets permanently fixed to the computer output channels.

The distribution system is split into two separate legs, serving roughly equal numbers of classrooms, each of which can have up to 12 channels of service. Routinely, six Public Broadcast System and commercial channels, the computer status channel, and five locally generated instructional channels are provided over each leg. When system usage is low, the same program appears simultaneously on both legs of the system. When it is high, different programs can appear on each leg.



The locally generated instructional channels may use source material from TV programs produced in West Point's commercial-quality TV Production Studio or from other source of videotapes. Other media can also be cablecast including externally produced educational films, Army-distributed films, locally produced motion pictures, text and tabular material, or pictures and graphics from the computer subsystem. Sometimes, the local production staff may operate live from the West Point TV studio, for example, to control the conduct of a final exam being held simultaneously in a large number of individual small section rooms. Occasionally, remote live pickups are arranged as with the annual Thayer Award from the Cadet Mess Hall.

The instructional television system also interconnects with a local community antenna television system, allowing selected instructional programs to be fed into faculty quarters. It is not uncommon for the Foreign Language Department to schedule evening language programs to be viewed as a part of class preparation for the next day. Occasionally, this leads to something quite unexpected. Last year one officer, who was deeply involved in preparing a manual on computer graphics programming, had a serious orthopedic operation. While he was confined at home recovering, he checked out a portable graphics television output and patched it into an unused channel of the CATV system which extended into his quarters. He proceeded to develop and debug his computer graphics programs from his bed, with the graphic output coming over his home TV programs.

Not all television is "on the cable." Videotaped materials in video-cassette form can also be used for class preparation or homework assignments, for study carrell-type applications, and for activities where it is not convenient to get to a cable outlet or where extreme flexibility in time of presentation or the ability to run and rerun at will are important. A simple industrial camera and monitor systems for certain kinds of live lecture-demonstration support and "creepie-peepie" systems are also used for informal recording and instant replay for self-critique. This is particularly useful for the improvement of physical skills (tennis serves, golf swings, etc.) and communicative skills (an instructor or a student debater seeing his own presentation as others see it).

With a long-standing tradition of small sections of about 15 men, and continuing back-and-forth interaction between student and instructor, West Point has few hour-long lectures and no lecture courses. The institutional philosophy of television usage must be distinctly different from that of most schools where TV is used to record whole lecture courses, perhaps freeing the instructor from 80% or more of his classroom duties. At West Point TV is most often used with an instructor present for a variety of applications: to bring things into the classroom that one otherwise could not; to assist in a more effective presentation; to give everyone a front-row-seat at a demonstration that always works properly,

to set an emotional mood; to assist in role-playing through the presentation of problems in skits; to present certain information in a standardized fashion to all sections of a course simultaneously; and to assist in the presentation of comprehension-testing material as in a foreign language instruction.

CONCLUSION

ISIS may seem to be technology over-extended, and it may prove to be so. So much capability may, at the present state-of-the-art, be too expensive to operate and maintain over the long haul. Only experience will tell, but, as technology advances, the same functional capabilities should become markedly cheaper compared to the cost of other academic overhead like books and the library, academic buildings and maintenance, and staff and faculty salaries.

Computers and television in education are expensive. The cost and complexity of the technology combined with the relative unfamiliarity of the typical faculty member with the new and rapidly changing technology of computers and television have forced a centralization of planning technical effort whenever a major program is undertaken. Any centralized activity has to work very hard indeed to maintain meaningful and effective interaction with the needs, objectives, desires, capabilities and limitations of individual students and instructors. User support rather than technological capability is the "Achilles Heel" of most educational technology innovation. Costs are meaningful, primarily in context of support provided. Even the most sophisticated system is relatively inexpensive compared to the academic building which houses it. Yet, the importance of user support is an omnipresent, driving force that shapes and molds any system and determines its success or failure.

ISIS is designed to offer the computer and television as *tools* to the instructor and to students in academic buildings and barracks, in classroom, in department offices, in learning resource centers in the individual academic buildings, and any place where learning is a primary focus of interest.

Tools can do nothing, however, unless they are properly understood and properly applied. ISIS is organized as an academic activity with faculty members, enlisted instructors and civilian professions to teach each faculty member and cadet how to use the tools, to consult with him, to work with him in class teamwork, to help develop programs and in every way possible to exploit the available capabilities to do a better job of instructing and training the Corps of Cadets.

Chapter 7

COMPUTERS AND TELEVISION: A Mix

by P.G. Charest

At the U.S. Naval Academy the office of the Dean for Educational Resources is primarily concerned with the cost effective utilization of the Academic and Administrative Computing Centers and the Educational Resources Center. Although concepts of operation are not exactly the same as those of West Point, both institutions agree that the melding of the immense communications capabilities afforded by the media of television and the broad power of an on-line computer system can make available to the instructor a dimension that has heretofore been lacking.

A midshipman with academic and professional courses, extracurricular activities and athletics is a busy young man. Although he is possibly no busier than other students, he does not have the option of allocating his time freely. There are specific guidelines on what he must do, and when. In an attempt to maximize the effectiveness of faculty allocation in the mandatory freshman computer course, to provide the student with maximum "individualized" attention, to maximize the student's learning experience, and to minimize his expenditure of time, a student monitoring system has been designed by the U.S.N.A. Computer Science Department.

COMBINING COMPUTING AND TV

Besides a computer system, operating under DTSS, with 144 terminal ports, facilities include a large, comfortable classroom and a CRT terminal

in that room which drives four TV monitors for all students to see. The CRT display on the television monitors allows instructors to quickly and clearly present sample programs and allows the students to see the results of the instructor's interaction with the time-shared computer. Simply by shifting the channel, a prepared presentation on some specific subject matter can be shown.

Would CAI without a monitoring system help? Not necessarily! Experimentation has shown the benefits to be inversely proportional to one's SAT scores. All benefit to some degree, but at the high end of SAT scores stand some 90% of Naval Academy students. Thus, the student monitoring system.

THE COMPUTING SYSTEM

There are two major prerequisites for the development of the type of system described below as a solution to this problem. First, the computing environment must be a time-shared one which makes the computer readily accessible by any student or instructor via terminal devices. Student assignment grades can be collected as the student interacts with instructor written assignment grading programs. The timesharing system also allows for efficient methods of developing and grading objective quizzes, updating student grade records, and extracting information from the records quickly as required. Secondly, the operating system must have a flexible file handling technique which allows for:

- Complete interaction of student or instructor saved programs with saved data files.
- A file protection system which permits the user to define what type of access (e.g., Read Only, Execute Only, etc.) may be granted to other users of his file or program.

A Time-Sharing system which incorporates this sophisticated disc file structure for user files represents a significant improvement in both speed and ease of maintenance over a card or tape oriented system. U.S.N.A. reliance on these features of DTSS is substantial.

One subsystem contains a student data base which can be accessed by a quiz grading and recording system, and an assignment grading and recording system. Output from the file is obtained through a grade reporting/monitoring system. Another subsystem has the ability to display any individual record and alter any field of any record. This subsystem can be used by any instructor who is privy to the several passwords which protect it. It provides the instructor with a method of direct control over the grades of his students despite the effect of any automated grade posting routine.

The assistance provided to the instructor in grading and recording programming assignments is centered around the Dartmouth TEACH system. The basic elements of this system are a monitor and a special set of

programs. In the USNA TEACH system for every homework assignment (a program), there is a corresponding set of programs designed to check the student's effort, help him in debugging, and post a grade for his effort in a file. When a student types the system command TEST under program name ROOT1, for example, the TEACH monitor is called. After making some modifications to the student's Basic program, the TEACH monitor appends it as a subroutine to the ROOT1 located in the special catalog. The entire package is then executed. When execution is complete, the TEACH program will have posted a grade in a file along with the student's alpha code, the date, the specific error made, and the time. The grade received depends on the logic of the TEACH program which determines what conditions were created by execution or calls to the subroutine which was the student's program.

An assignment evaluation system like the TEACH system is not dependent on what it evaluates. Specifically, it need not be designed to evaluate computer programs. The only real requirements are that the student's effort be objectively measurable and that he be able to access a program to examine his work. The program which does this may simply examine and grade the student's effort or it may provide interactive guidance.

As a safeguard against the loss or destruction of a student grade in memory, all students who receive an A on the assigned program after typing TEST are printed a "receipt" for that A. An example of a typical TEACH program interaction is shown as Figure 1.

The example in Figure 1 illustrates an error on the part of the student, the receipt of diagnostics, the correction of the error, and ultimately the awarding of a written receipt. A review of the error exits for the students in one's section can be enlightening. Maybe an explanation wasn't so clear after all.

During the fall of 1974, Dean's office staff are video taping an entire course, not in the standard 45 minute lecture period format, but rather by subject matter. Should the student repeatedly have difficulty with a concept like looping, one of his diagnostics would direct him to review the applicable video tape. The same tapes are invaluable to the hospitalized student. By viewing them in the proper sequence, he can keep up with his classmates.

Another subsystem aids in the writing, grading, recording, and analyzing of quizzes given. For any multiple-choice quiz, once the number of questions is stated, it will randomly select the specified percentage of questions from specified files, concurrently preparing an answer gauge. Questions can be filed by complexity or by subject matter. The file into which the quiz was stored can then be printed out, one page at a time, on ditto mats fed into the teletype. Endless unique quizzes can be thus

prepared. Students mark their answers on optically read mark-sense cards which are read into the system and graded according to the gauge automatically prepared for that quiz. Grades are automatically recorded. The student can view his grade files at any time, reviewing the correct answers to the quiz and noting how well, or how poorly, he did.

Should a portion of the quiz have been a short program that had to be hand graded, the grades could be entered into the computer file by the instructor and a plot of the grade distribution reviewed. At the end of each marking period, student grades can be computed by assigning a specific percent to each quiz, homework assignment, and exam.

LIST

ROOT1 03 OCT 74 21:34

```

10 / PROGRAM TO FIND THE ROOT OF THE EQUATION
20 /
30 / F(X)=A*X^3+B*X+C
40 / D<=X<=E
50 /
60 / USING THE BISECTION TECHNIQUE.
70 READ A,B,C,D,E
80 DATA 2,-20,6,1,10
90 LET L=D
100 LET H=E
110 LET F1=A*D^3+B*D+C
120 IF H-L<.00001 THEN 200
130 LET X=(L+H)/2
140 LET F2=A*X^3+B*X+C
150 IF F2=0 THEN 200
160 IF F1*F2<=0 THEN 180
170 LET L=X
175 GO TO 120
180 LET H=X
190 GO TO 120
200 PRINT "EQUATION: ";A;"* X^3 + ";B;"* X + ";C
210 PRINT "RANGE: ";D;"<= X <=";E
220 PRINT "ROOT: X =";X
230 END
READY

```

RUN

ROOT1 03 OCT 74 21:35

```

EQUATION: 2 * X^3 + -20 * X + 6
RANGE: 1 <= X <= 10
ROOT: X = 1.82587

```

0.354 SEC. 26 I/O
READY

Figure 1. Example of a Typical TEACH Program Interaction.

Feedback to the instructor is available in many forms. The most comprehensive is a listing, by section, of each student's complete grade record. Should the instructor desire only to note which students had trouble with one quiz or a combination of quizzes, he can set limits on maximum grades to be displayed for a specified section.

If the instructor desires to review homework assignment grade distribution, and the same for quizzes and periodic marks, specialized displays are available. A specific record or group of records can be checked as well.

TEST

ROOT1 03 OCT 74 21:35

Hello MIDN. COMPSCIDEPT,
TEST IN PROGRESS.
YOUR PROGRAM DOES NOT FIND THE CORRECT ROOT FOR
THE TEST DATA. IT APPEARS THAT YOU ARE EITHER:
--NOT CALCULATING THE MIDPOINT PROPERLY.
--NOT COMPUTING 'AX³+BX+C' PROPERLY.

81234091C21003742135
Partial credit has been recorded -
To improve your grade, try again please.

2.420 SEC. 115 I/O
READY

TEX REP B+X,B*X,140
0.075 SEC. 4 I/O
READY

TEST

ROOT1 03 OCT 74 21:36

Hello MIDN. COMPSCIDEPT,
TEST IN PROGRESS.
CONGRATULATIONS. YOUR PROGRAM WORKS.

Your grade has been recorded. Sign this
and save it as a backup in case of computer failure.
If requested, turn it in to your instructor.

10/03/74 21:36:28 Name -----
81234091E5

2.431 SEC. 115 I/O
READY

The main line of defense against inaccuracy, loss, or destruction of information is the inherent reliability of the Honeywell-635 and USNA/DTSS. Low down-time complemented by a sound policy which specifies frequent full and incremental dumps has so far prevented any serious loss of information.

In a time-shared environment using dynamic storage allocation techniques, a crash can result in the loss of some information stored between the time of the last dump and the crash. When this happens, lost quiz grades can be recovered by regrading the cards, and reconstructing the answer card files if necessary. In cases where the quiz grades had been entered by hand, they are simply re-entered by hand. Student receipts also serve as proof of homework assignments completed between last dump and the crash.

The present system of programs operates relatively smoothly. Several improvements are in the process of being implemented, however, in order to increase the efficiency of the system.

A system such as described above represents a useful tool for any instructor but is probably most helpful to the instructor of large classes whose performance can be must be frequently measured in an objective manner.

CONCLUSION

One could ask whether automation dehumanizes the course. At U.S.N.A. the reverse is true. Instead of spending class time on administrative and grading details, the instructor can devote himself to the thought processes of the humans who are sitting in the classroom. For those students unwilling to admit, to their instructor at least, that they cannot understand specific concepts, the computer can determine the weakness and the video tape can clarify the point.

Chapter 8

THE COMPUTER AND THE CAMERA: CAI and CATV — The Missing Link?

by John J. Hirschbuhl

INTRODUCTION

At the University of Akron, computer-assisted instruction has been serving as a supplementary classroom tool for the CATV system since the fall quarter of 1972. The major objective has been to help teachers function more effectively by enabling many students and a single teacher to engage in a one-to-one dialog, with a high-speed digital computer as the communications medium. What transpires in effect is a highly individualized form of instruction made possible by the interactive and record-keeping capabilities of the computer system. As a result, the teacher is able to monitor and tailor instruction to fit a student's needs without physically sitting at the student's elbow.

To date we have served more than:

- 700 students in Basic English Grammar
- 400 students in Basic Mathematics Skills
- 900 students in Introductory Chemistry
- 600 students in Tests and Measurements
- 300 students in Research Techniques
- 450 students in Introductory Statistics
- 100 students in Introduction to COBOL
- 200 students in Mathematics Education
- 200 students in Reading

- 150 students in the study of steel design modules
- 1000 students in various games and other mind extenders.

INSTRUCTIONAL DESIGN FOR A LEARNING RESOURCE CENTER

Although this capability is of substantial benefit to students and the faculty, the methods of delivery and coordination between it and our CATV system are still rather primitive and in many ways lack the precise synchronization of technology that most certainly will come about within the next decade.

The following instructional design has been implemented in several of the University's survey courses in the learning resource center. The purpose of the design is to give the instructional system a high probability of providing a multi-media delivery system that will assist students in achieving a set of well-defined instructional objectives. (See Figure 1.)

This model requires that the instructional program supply the resources needed for assessing student entry level into a given objective. Such pre-testing provides the system with a vehicle for assisting students in choosing the teaching mode they prefer on a given topic. In order to funnel the selections to an appropriate set of choices, student performance is compared to well-defined criteria. If the student matches the criteria he is offered a choice of instructional mode; if his performance is less than the preset criteria he is directed to a laboratory type of instruction; if he exceeds the criteria he is moved to the next objective. It is through such a process that instruction is delivered in a style that meets the student's level of development. The necessary data supply for this decision-making is collected by means of on-line testing.

A MAJOR PROBLEM

Up to this stage our present computer software, hardware, and communications gear is well suited to the task of supporting the instructional logic. At the point of methods selection, however, the hardware fails to live up to the demands of the instructional design.

At the present time the student who chooses any form of instruction other than computer instruction is forced to leave the interactive system to which he has been attached. For example, if he decides to make use of the audiovisual instruction provided by CATV, film loops, or audio tapes, he must leave the computer terminal instruction station and manually initiate instruction through his chosen media. The major problems connected with such an interruption are:

1. an inability to record electronically the student's use of the other media and his position in its program;
2. a lack of interactive capabilities in the other media;

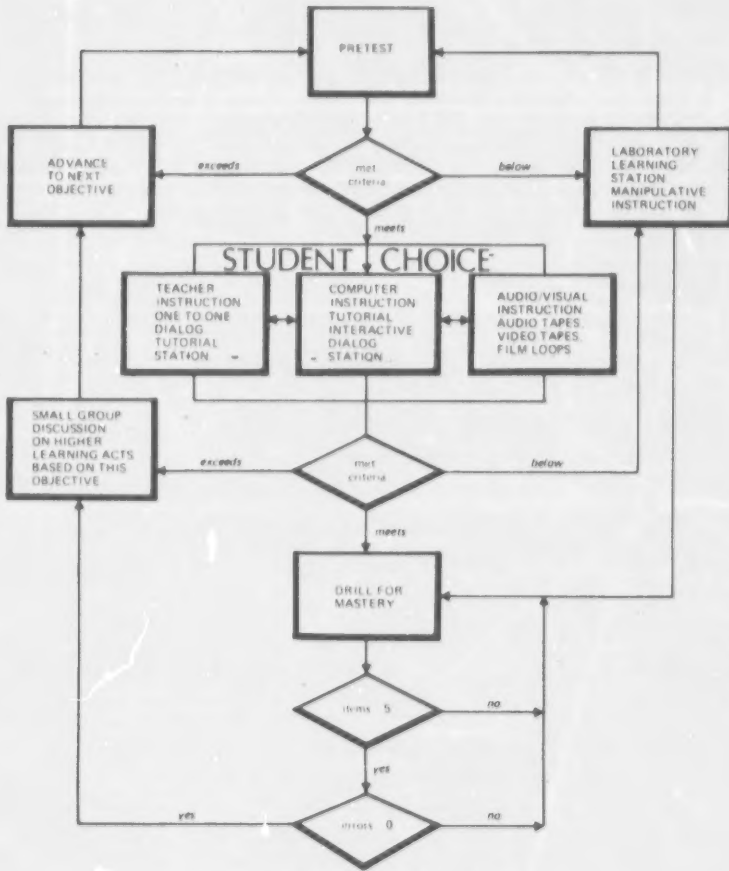


Figure 1. A Model for Student Choice

3. the sometimes unavoidable scheduling interruptions that occur with the limits of available materials on a one-to-one basis (i.e., the tape or film loop is being used by someone else, or all other CATV terminals are in use);
4. the change in media necessitated by post-assessment under several of the off-line instructional options.

If the CATV, the audio tapes, and the other media were deliverable under computer control at the same instructional station, then the four deficiencies noted above could be overcome in both the Laboratory Learning Stations and the A/V Instructional Stations.

A POSSIBLE SOLUTION

Within the next decade the videodisk can solve this problem. However, before it can be of any benefit such a disk must be both technologically and economically practical. Until a dynamic and versatile CAI-CATV system can be provided, both CAI and CATV will continue to fall short of the full promise they held forth only a decade ago. The videodisk is an idea whose time has come. However, it is an idea that has been thwarted by lack of a visible demand for such a device. It is time for educators who are concerned with the development of CAI-CATV systems to make known to the vendors their need for this missing technological link. Educators cannot be expected to provide the optimal system of instruction as long as they do not have hardware and software designed for such a task. At present, the computer industry gives a casual nod to education. What is needed, though, is a thorough examination of the educator's needs and a new approach to developing computer terminals and storage devices based on the fundamental principles of learning theory.

FILLING THE GAP

Because of the shortcomings discussed above, today's CAI-CATV systems are forced to utilize the most versatile and patient learning system that has yet been developed — the human teacher. As part of the instructional selection mode of our current system, the student may choose a human tutor for direct one-to-one learning. Many studies done by contemporary learning theorists support the validity of providing such an option. In fact the entire instructional paradigm of the CAI system is based on the tenets of educational psychology regarding learning readiness and the need for a variety of instructional opportunities. However, when the student chooses to utilize the human tutor option, the problems generated by a change in media come into play. They are:

1. getting information to the tutor on each student's position in the learning sequence (i.e., objective mastered or not mastered);
2. the change in media necessitated by post-assessment (i.e., at the end of the tutoring session, the student must be routed to the terminal for post-assessment).

We are faced with the dilemma of providing a variety of instructional choices while at the same time not giving up the data collecting capabilities that are part of the CAI-CATV system. Besides, how do we maintain a constant response system in such a situation? However sound our design may be, we are left with the thorny problem of finding a method for systematically storing data on student performance when he is not under the watchful eye of the computer.

One way that the University of Akron's paradigm attempts to overcome such shortcomings in computer-human learning relationships is by using

small group learning sessions. These sessions serve as a culminating learning experience for all CAI-CATV instructional programs. However, they are difficult to schedule, and they lack some of the spontaneity that could be provided if the CAI-CATV system had its own interactive capabilities. Currently, using individual student performance as a basis, the computer schedules small interactive sessions of students who are ready for a group experience. Because each learning system revolves around one well-defined objective, these sessions are available to a student only after he has mastered the current objective. He is then ready to use the skills associated with the objective to explore higher learning activities through group interaction. If the student has not mastered the objective but has a rudimentary understanding of the skills involved, he is directed to a drill and practice session. These sessions, which make up a significant part of our computer-assisted instruction system, are provided to assure that those who have failed to master an objective in the instructional activities they have experienced thus far will cement their knowledge of needed basic skills. In this way the marginal learning that has taken place is fixed for future use and development in the small group discussion sessions.

SUMMARY

This presentation has pointed to the achievements and the problems that have been experienced by one university in its attempt to provide a CAI-CATV system that blends man-machine delivery systems for instruction of its students. It is to be hoped that today's computer systems are close to providing a complete instructional system, but obvious gaps remain. The gap between the system itself - - CATV - - and man is perhaps the most significant one. Until it is closed the development of CAI-CATV programs will continue to be a slow, tedious, and troublesome task. If the steps being taken in the TICCIT project do not succeed, one may not see the development of a true two-way CAI-CATV system for twenty-five or more years.

Chapter 9

ATTITUDE: The Missing Link

by William Mavrides

In Chapter Eight Dr. Hirschbuhl suggests that The University of Akron has all of the ingredients necessary for completion of a highly effective and efficient instructional delivery system with but one exception — a unifying electronic link which will effect the closure necessary to complete such an ideal delivery system. Perhaps he is correct, perhaps not. This paper argues that the psychological barriers to the acceptance of technology in higher education may be more important than an electronic missing link.

One recurring block to the efficient and effective use of the highly sophisticated learning tools which have been available for almost two generations is the fear of academically oriented colleagues of technical nomenclature. As an example, the term "delivery system" is innocent and innocuous enough at first glance. But think of the image it conjures up within the minds of some imaginative yet conservative and insecure colleagues!

A prime and most familiar analogy is that of the corner butcher shop where one orders and pays for neatly packaged, highly necessary, and visually stimulating steaks, roasts, and chops, all products easily available highly necessary, and yet only temporarily lasting in terms of need satisfaction. Advocates of the use of television and computing for instruction are often viewed as purveyors of neatly wrapped consumable educational stuffs. Because the buyers feel "cheapened" they oppose any innovation.

Dr. Hirschbuhl and counterparts, I admonish you to reexamine your language skills. The description of technology may be more important than the potential benefit to instruction in overcoming faculty resistance to a particular technological innovation.

Let us also recognize that computing and television are support systems and services, to be used as tools or instructional aids. The projector and tape jockeys who feel that, "If it cannot be cut, pasted, photographed, projected, or programmed then it cannot be learned," are horribly miscast in their self-made roles as teachers and scholars. Is not the most obvious and pressing missing link a behavioral one? Should not the advocates of the widespread use of computing and television in higher education learn and practice with greater finesse roles as enablers and facilitators. Until such advocates recognize their proper places within the educational hierarchy, they will continue to meet frustration, and delaying and obstructionist tactics of all kinds and types in their efforts to improve learning. If one continues to frighten and threaten with "black boxes," one will always have difficulty in advancing and improving learning and teaching. Threatened people cannot learn because they are to preoccupied with their own fright. Threatened faculty will not adopt technology for instruction.

There is no educational institution which does not now have the capacity and ability to move education ahead with efficiency, effectiveness, and increased productivity at all levels. The missing link is one of attitude not electronics. It is people who advance, delay, retard, or cancel progress.

There is nothing today within the broad framework of education which cannot be linked together mechanically and electronically for the betterment of understanding. The transmission of photographs through wire and air is an everyday routine for the news media. Television, radio, and silver screens transmit both past recorded history and instantaneous happenings as matters of course. Books, tapes, discs, newspapers, magazines, and even lowly billboards transmit information. Systems of receival and dissemination exist. The quality of what is put into them may well be the determining factor regarding administrative attitudes about final and crucially needed financial support for provision of the disc, the wire, or the receiver — the "missing link" of hardware.

THE UNIVERSITY OF AKRON EXPERIENCE

The University of Akron began using closed-circuit television on a broad scale in 1960. In 1974 an average of approximately twenty-thousand class registrants per year routinely received some part of their instruction via television either in individualized carrels, in small classroom settings, or both. With the inception of closed circuit television the University also built into the system a "talk-back" capability which permitted students to question instructors from individual viewing stations. This system no

longer exists. Was it the administration who eliminated it? Not at all! Faculty members who resented being interrupted by students during lectures stopped its use! One of these was a behaviorist who publicly lamented about mass educational practices with their correspondingly increasing loss of individual student identities. The year? 1963!

In 1962 the university simulated a closed-circuit TV-computer linked demonstration. Through mechanical and electronic means students at computer keyboards were instructed by print-out directives to refer to textbooks, audio and video tapes, and films, for reinforcement and remediation purposes. The student had to call the TV studios to request particular video tape segments. At other times the CAI keyboard linked him or her to New York and California for related instructional materials. In 1962 a response in nano-seconds was not necessary. This slow system did work.

In 1974, CAI is only one of the university's regular instructional services. Video display units and the CAI Center function as a regional network center. Public schools and other higher education institutions from within and without the state make routine use of all available university CAI programming.

Magnetic video-discs which would make the laboratories a truly complete electronic learning system are soon to be available from industry at affordable economic levels. Institutions such as The University of Akron cannot yet afford the dollar investment to purchase complete video-file and instant replay video systems. However, there is still much that can be done with existing equipment and improvisation and dedication can perhaps gain that pinch of additional financial support which is needed from boards of trustees and administrators. Again the human commitment is the missing link.

The University of Akron in 1974 is linked to one of the most extensive privately owned two-way cable TV systems in the United States. Is it being used? Not at this point in any Open University sense. Too expensive? Perhaps. On the other hand, the faculty have not demonstrated a readiness to use this additional tool.

A PROPOSAL

Perhaps a beginning can be made on each campus and in each region for development of Learning Resource Centers. The elements exist including hardware, programming, students, and an ever-growing group of dedicated, energetic, curious, and experimentally minded teachers and learners. The University of Akron 1962 definition of an LRC may be a useful model.

"Within the framework of The University of Akron the Learning Resources Center will collect, produce, and organize for use in an interrelating complex those materials, devices, media, techniques, etc.,

which singularly, or in concert, will facilitate the advancement, transmission, and assimilation of knowledge in harmony with the objectives of the institution. Theoretical and practical research into the learning processes of groups and individuals will be undertaken. The operations of the LRC will be coordinated with all other university functions so that the total campus intellect and experience will be brought to bear more efficiently and effectively on the teaching-learning task."

In summary, the missing link is one of attitude. The question today is no longer how are colleges and universities to use technology for instruction? It is, "When are they going to proceed?"

Part III

**Computers and
the Learning
Process**

Chapter 10

COMPUTERS AND THE LEARNING PROCESS

by John F. Rockart

In order to discuss the impact of computers on learning, it is important to understand the learning process, the manner in which people obtain and assimilate knowledge. One must have a working model of the learning process if one is to design computer systems to assist it.

Everyone does have *implicit* models of what learning is, and therefore, how computers can assist this process. Further, each uses his or her implicit model when designing computer systems to assist learning. The real need in the field is to make these models explicit. Only then can we lay bare the assumptions upon which each bases the fundamental design of computer-based learning aids. These assumptions, are critical for they significantly influence the type and exact form of the computer tools designed to assist the learner.

This chapter presents some conclusions that Michael Scott Morton and the author have drawn as a result of reviewing the literature in the field of technology-assisted learning, and also of working, in the field periodically over a period of several years. An expanded version of this paper, which may fill in the many chinks these few pages leave open, will be available in 1975 in the book *Computers and the Learning Process in Higher Education*, to be published in the Carnegie Commission series on Higher Education.(9)

The search for a precise model of the learning process is a difficult one. Unfortunately the majority of published material with regard to the

learning process, while intellectually rewarding, is of little assistance to the designer of computer-based learning aids. What is needed is an operational statement of the learning process that can be acted upon in the design of course materials, the design of a pedagogical strategy, and the assessment of a place of computer technology in that strategy.

A precise model enables one to describe and partition the possible impact of various technologies on segments in the learning process. Of equal importance, it enables others to test and offers conclusions about the effects of the technology with reference to the stated model. Finally, others can test the author's conclusions against original models of the learning process, and determine whether differences in perspective are based on differing perceptions of learning or differing perceptions of technology.

The particular view of the learning process, and how it can be aided by computers, is presented here not as the "right model. Rather, it is an explicit model of the learning process which is operational and useful as a point of departure from which to build systems to aid education.

THE STATE OF LEARNING THEORY

Over the years learning has been considered primarily the domain of psychology. Since the mid-1880's when the first really useful work on memory was published (1) there has been a series of attempts at explaining learning phenomena. Unfortunately, many of these attempts have been at or near the level of grand theory and have been in conflict with each other. A good summary of these theories is found in Hilgard and Bower (1966) (2).

In general, two major theories of the learning process have dominated the field through the last few decades. These are known as the stimulus-response (SR) theory, and the cognitive theory. A third major theoretical approach to learning, that of Piaget, has also entered this field more recently but will not be discussed here. As Figure 1 shows, the two

	<i>Stimulus-Response</i>	<i>Cognitive</i>
PROCESS TYPE	Chained Muscular Response	Central Brain Process
WHAT LEARN	Habits	Cognitive Structures
NEW THINGS LEARNED BY	Applying Closest Old Habit—Or Trial and Error	"Insight"—Comparison with Old Structures

Figure 1. Basic Differences in Two Major Learning Theories

major theories can be separated on three major characteristics. The stimulus-response school (perhaps best known through the experiments and written works of Pavlov and Skinner), suggest that what one perceives as learning is merely a chained muscular response. In effect, the SR school

suggests that people learn habits and learn new things by applying the closest old habit until one fits the situation. If there is no old learned habit that comes close to fitting the situation, one learns through trial and error. The cognitive school, on the other hand, (represented by psychologists such as Tolman and Bruner) suggests that what goes on is really a central brain process in which the learner learns cognitive structures which are similar to computer programs. New things are learned by "insight," which is a process of comparing new situations with old cognitive structures. Exactly how this occurs is unexplained. Clearly, the latter theory is somewhat more appealing. Skinner's (1972) (10) writings, which reflect the SR theory, remove all free will from mankind. But personal choice of theory, intuitively or logically, is not important. What is important is the usefulness of these theories in designing learning aids.

Unfortunately, it is almost impossible to use these theories pragmatically. The only viewpoint one can take, and have explicit action flow from it, is a strict SR stance. If one does so, one is thrust in lock-step mode toward the exclusive use of Skinnerian programmed learning. Whether explicitly or implicitly because of this, much of the early work done in the field of computers and learning followed these lines. Yet this approach seems far too single-minded to encompass the entire field of learning with the richness and variation which it holds.

Existing learning theories suggested only generalized (and/or single-minded) approaches to technology. They left too few *specific* knobs to turn and failed to suggest specific areas of potential success for learning technology. They also failed to provide guidance for the most useful action steps that could be taken to utilize computers, as opposed to other learning aids, by the individual professor with a particular course to teach. Dave Kolb, a colleague at M.I.T., has summarized the pragmatic failures of these theories well (4):

"Because of my early psychological training in learning theory my first impulse was to turn for the answer to these questions to the basic psychological literature on this subject. To my dismay I found that, in spite of the high scientific quality of this work, it was immensely difficult to apply this research on reinforcement theory, discriminative learning and such to the kind of practical decisions involved in the design of university teaching."

Work of practitioners in the field of learning, as well as the theorists, was reviewed in an attempt to elicit a useful learning model. Five sets of critical variables with regard to learning emerged from a search.

- The stages of the learning *process*
- The characteristics of the *material* to be learned
- The characteristics of the *learner*
- The characteristics of the *teacher*
- The learning *environment*

Of these five categories, the first two appeared most significant for

modeling. The last two are very complex variables which are terribly difficult to model. At the time of the development of the model, presented here, the third variable was not as well researched as it is at the time of the writing of this paper. Therefore, it was not included.

The model of the learning process presented here was limited to two variables which seemed significant, operationally describable, and least apt to be changed by the conclusions from the study. These two variables are the "stages of the learning process" and "characteristics of material to be learned."

STAGES OF THE LEARNING PROCESS

The search for an operationally useful statement of the learning process is not an easy one. However, one model developed by behavioral scientists can be generalized to the learning process in all fields.

The behavioral approach to describing the learning process which serves as the basis for this model follows the work of Kolb.(4) Reacting to the frustration of the inapplicability of learning theory for the practical educator, and needing something to guide his efforts in the educational process, Kolb turned to the so-called experiential learning model (see Figure 2) that, adapted somewhat, has been used as the core of our work.

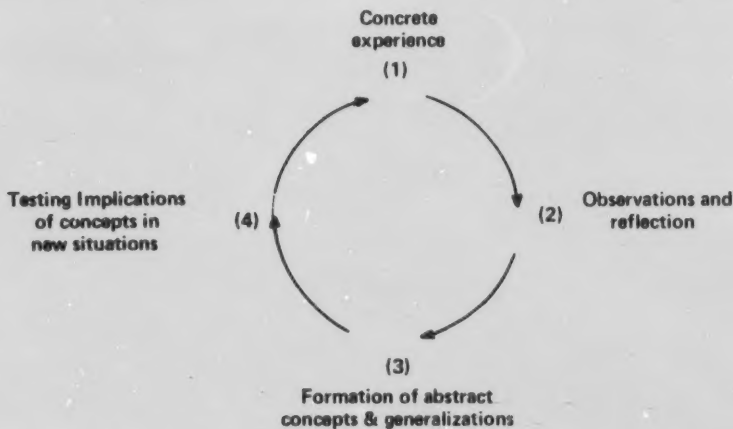


Figure 2. The Experiential Learning Model

Developed primarily out of the experience of sensitivity-training practitioners, (7) the model has gained increasing acceptance as a framework for the design of learning programs. It has been used in such diverse areas as education, (5) the incident process in management training, (6) Peace Corps training, (11) and self-assessment. (3)

In this model, learning is conceived as a four-stage cycle which translates experience into new concepts. Immediate concrete experience (step 1) is the input to step 2 where the meaning of the experience is embedded and "understood" through observation and reflection. In step 3, these observations are assimilated into a theory or conceptual basis from which new implications for action can be deduced. Finally, these implications are tested in the real world in new situations (step 4). The testing process leads to a need for new concrete experiences and the loop is closed.

It is important to note that the experiential learning model depends on the learner undergoing some sort of experience that provides an initial set of facts or feelings as input to the learning cycle. It is clear, however, that most of what is learned in college is not based on an initial experience, but rather on the acquisition of new facts or skills. The behavioral model, however, can be generalized without too much difficulty. In this more general form, the model appears as in Figure 3.

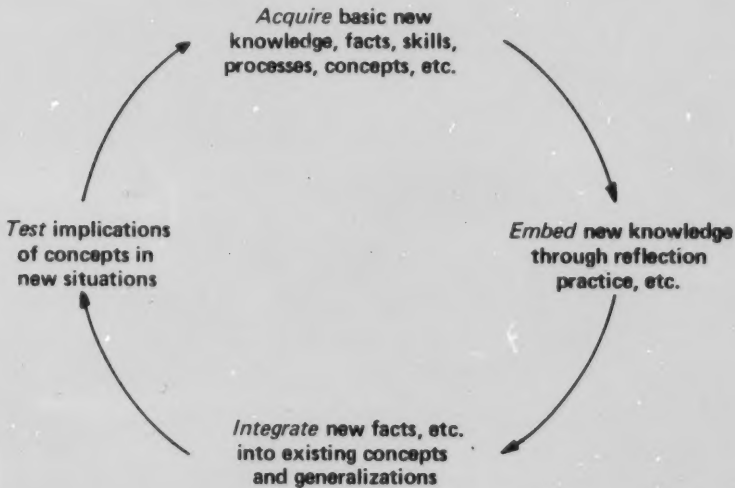


Figure 3. A General Learning Model

The initial stage of this more universal learning model is the initial acquisition of basic components of knowledge by the student. Here the learner is exposed to, and asked to comprehend, basic data, skills, or concepts that will be put to use in later steps.

The second stage is the "salting away" or embedding of this knowledge by the learner. In this stage, the student practices and ponders new skills. The student may perform homework exercises to see if he or she has understood the new facts and how to apply them. The student may actually

use the skills in the performance of a task, or may merely think through the facts, skills, or processes.

The learner then moves to the third stage of this general model, a stage in which the new ideas assist in the development of a new conceptual grasp of the world. This is an *integrating phase* in which the student moves from the rote acquisition of material to its incorporation and subjugation into more global conceptual structures. It is the stage in which the learning of new things pays off in new understanding. New mental models of the universe, or parts of it, are formed. Robust platforms, on the basis of which action can be taken, are constructed.

The testing of new conceptual structures is the final phase. It is a phase at which the cycle is often broken in formal, university-level education because today there are few pedagogical mechanisms available to the student by which he can test the implications of his new understanding. The richness of the learning process is broken, too, as new conceptual bases are learned, and then stored away to gather dust. Stage 4 is clearly more often reached in courses run along experiential lines, such as "executive" programs or courses allowing access to a pseudo real-world environment, via simulation models.

THE MATERIAL

The second major variable considered in our learning model is the material¹. Many different categorizations of material can be presented. The problem is to provide a set that is meaningful throughout most disciplines and that can be utilized to describe each learning area in an operationally useful way. One such categorization commonly used in the learning literature applicable to various disciplines and useful in its description of their material.

- *Facts*, including definitions and other basic information relating to specific single items or ideas
- *Skills*, including both procedures and rules and their applications
- *Established concepts*, as well as other theories, hypotheses, postulates or assertions that are well enough established to be of no interest to the current researchers in the field. "Concepts" use "facts" as basic building blocks in constructing the concept
- *Frontier concepts*, including not only recent developments but also long-standing issues which either have not been, or cannot be, resolved

For any particular course or department, this breakdown of material can easily be further divided. Category 2, skills can and perhaps should be broken down into several highly distinct types of skills. Indeed it is necessary to subdivide these categories further when dealing with a particular course. However, across courses and departments, this four-part categorization serves as a good vehicle for understanding the applicability

of technology to particular curriculums. It was meaningful to several colleagues who were able, in a survey, to easily classify the material taught in their courses within the bounds of this classification. Certainly the relative emphasis on these four categories of material will vary with particular university departments and with differing degree-level programs. This, in turn, will mean that the type of learning technology that can be effectively employed will also differ from course to course. Yet the four classes of material appear to be a reasonable division of material types.

AN OPERATIONALLY-USEFUL LEARNING MODEL

The basic learning model, then, has two variables, learning stages and material classes, that together produce 16 cells as shown in Figure 4. It is

	Acquisition	Embedding	Integration & Generalization	Testing in New Studies
Facts and Definitions				
Skills and Procedures				
Established Concepts				
Frontier Concepts				

Figure 4. A Learning Matrix

this two dimensional structure which must be confronted when asking the question as to where the computer fits in the learning process. The process involved in learning in each of the cells is different; and the technology utilized must be fitted to these differences. Therefore, the computer fits in differing ways into each of these cells; in some it is not very useful at all today.

The fundamental proposition this suggests is that one cannot think of the use of the computer in learning as a whole without doing a great disservice to the variety of material and the complexities of the differing stages of the learning process. The computer must be expected to be utilized in different modes in each area (or each cell of the model shown in Figure 4). Some of the cells, are almost impregnable by computer aids to learning currently available. Others are ripe for differing types of computer assistance to the learning process.

The following paragraphs briefly note the many "learning aids" available to assist learning, analyze the learning demands of each of the cells of the learning model, and then attempt to match the appropriate technology to these demands. In this paper, because of space and time, this is done in a very cursory manner. For a fuller explication the reader is referred to Scott-Morton and Rockart.(9).

Learning aids. It is clear that today a large set of mechanisms are available to assist learning. These include the professor who can lecture, lead a class discussion, etc.; books; video tape; and computers which can be used in tutorial mode, for drill and practice, for gaming, or for simulation. Each of these mechanisms can be rated for effectiveness on a well-defined set of attributes. For example, some mechanisms are very economical per fact presented. Some like text books have the attribute of decentralized availability. Computers in most cases today do not. Other attributes such as emotional impact, sensory impact, the ability to telescope time, are possessed to a greater or lesser extent by each learning mechanism. A set of sixteen of these attributes are defined in Table 1.

Table 1.
Summary of Attributes of Learning and Delivery Mechanisms

- I. *Content Related*
 1. Ability to telescope time
 2. Ability to present structure
 3. Provision of a rich environment
 4. Ability to provide ill-structured material
 5. Flexibility for adding new material quickly
 6. Support for the learners' structured, clerical tasks
 7. Support for unstructured data manipulation
- II. *User Related*
 8. Degree of learner control
 9. Ability to adjust to individual learner needs
 10. Ease of use
- III. *Communications Related*
 11. Amount of sensory impact
 12. Amount of emotional impact
 13. Degree of learner feedback
 14. Ability to access data or concepts previously learned
- IV. *Economics*
 15. Low cost per data item or concept
 16. Decentralized availability

Learning aids available in 1974 vary widely along many dimensions with regard to each of these attributes. The major learning aids and our ranking

of them on each of the sixteen attributes (where 1 = high and 10 = low) are shown in Figure 5.

Attribute		Content					User				Communication				Economics		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Mechanism																	
AUDIO																	
	Lecture	5	3	8	1	1	10	10	8	1	5	5	3	8	10	3	8
	Case Disc.	5	10	3	3	5	10	10	8	5	5	5	5	8	10	5	10
	Class Disc.	5	10	3	3	1	10	10	8	8	5	5	5	3	10	5	10
	Tape	5	5	8	5	3	10	10	5	10	5	5	5	10	5	5	3
	Radio	5	5	8	5	3	10	10	10	10	3	5	5	10	10	5	3
VISUAL																	
	Visual Aids	5	3	10	10	1	8	10	10	8	5	3	5	10	8	5	10
	Film	1	3	5	1	10	8	10	8	10	8	1	1	10	8	8	5
	Video Tape	1	3	5	1	5	8	10	8	8	8	1	1	10	8	8	5
	Cable TV	1	3	5	1	5	8	10	10	10	5	1	1	10	10	8	3
WRITTEN																	
	Text Books	5	3	8	3	10	10	10	10	10	1	8	8	10	5	1	1
	Prog. Instr.	10	5	10	10	8	10	10	10	8	1	8	10	3	8	3	1
	Study Mods	10	3	10	5	8	8	10	8	8	3	8	8	5	8	3	1
	Written Assn.	10	5	10	10	5	10	3	8	8	1	8	8	3	8	10	1
COMPUTER																	
	Tutorial	10	5	8	10	8	10	10	5	5	5	8	10	3	5	5	3
	Drill Pract.	3	5	8	8	3	5	5	3	5	5	8	8	1	5	5	3
	Prob. Solv.	1	5	5	8	8	3	1	3	3	5	8	8	1	3	8	3
	Inquiry	8	8	1	1	8	5	8	1	3	5	5	8	5	1	10	3
	Simulation	1	5	1	1	8	1	1	1	3	5	3	5	3	3	10	3
	Games	1	5	3	1	8	1	3	3	3	5	3	3	5	5	10	3
OTHERS																	
	Expts, Lab	5	5	1	10	8	10	10	3	10	8	5	8	1	10	10	10
	Expts, Real World	10	10	1	10	5	10	10	3	5	10	3	3	5	10	10	8

Figure 5. Appropriate Learning Aids for Specific Attributes

Learning Demands of Each Cell. The matrix shown in Figure 4 suggests that each of the 16 cells are somewhat unique and thus that the type of learning that takes place in each cell requires differing types of learning assistance. Just as the learning aids notes above have different attributes, the cells of the learning matrix need different types of learning assistance and must be matched by the choice of that (those) learning aid(s) which best fit these needs.

Four examples may best illustrate the concept of matching the correct learning aid with the learning process requirement of each particular cell. The upper left cell of the matrix (the acquiring of facts) has two key learning attributes needs as shown in Figure 6. Because there are many

	Acquire	Embed	Integrate	Test
FACTS	COST DECENTRALIZED AVAILABILITY	FEEDBACK some learner control		
SKILLS				
ESTABLISHED CONCEPTS				
FRONTIER CONCEPTS	ADD NEW MATERIAL give structure to ill structured material ADAPTABLE			DATA BASE MODELLING ABILITY MANIPULATION ABILITY

Figure 6. Significant Learning Aid Characteristics "Demanded" by Cell

facts to be learned, the learning tool which aids this learning should be cheap, and available whenever and wherever the student wishes. Clearly the learning aid which ranks high on these attributes (#15 and 16 from Table 1) is the textbook. Relative to all the other learning aids it is clearly dominant at the present time with regard to economy of presentation of facts and decentralized availability.

Moving to the lower left corner of the matrix, a different situation exists with regard to the acquisition of frontier concepts. Here one is looking for a learning aid which can structure ill-structured material. The dominate learning aid here is clearly the professor, most probably in lecture or class discussion mode.

Now shift to the lower right-hand corner of the matrix. For the testing out of frontier concepts in areas other than the one in which they were learned, it is clear that the learner needs the availability of a large data

base, methods of manipulating this data base, and a method of trying out the concepts in a way which does no harm to anyone. This testing out process has been done in the past in the real world quite often resulting in some damage to both the testees and the testor. However, the ideal learning mechanism for this cell today, is not the real world, but rather computers and simulation models. The student can adequately test out ideas in a simulated world if he or she has access to enough data and enough computing power. The learning aid of choice thus becomes *computers*.

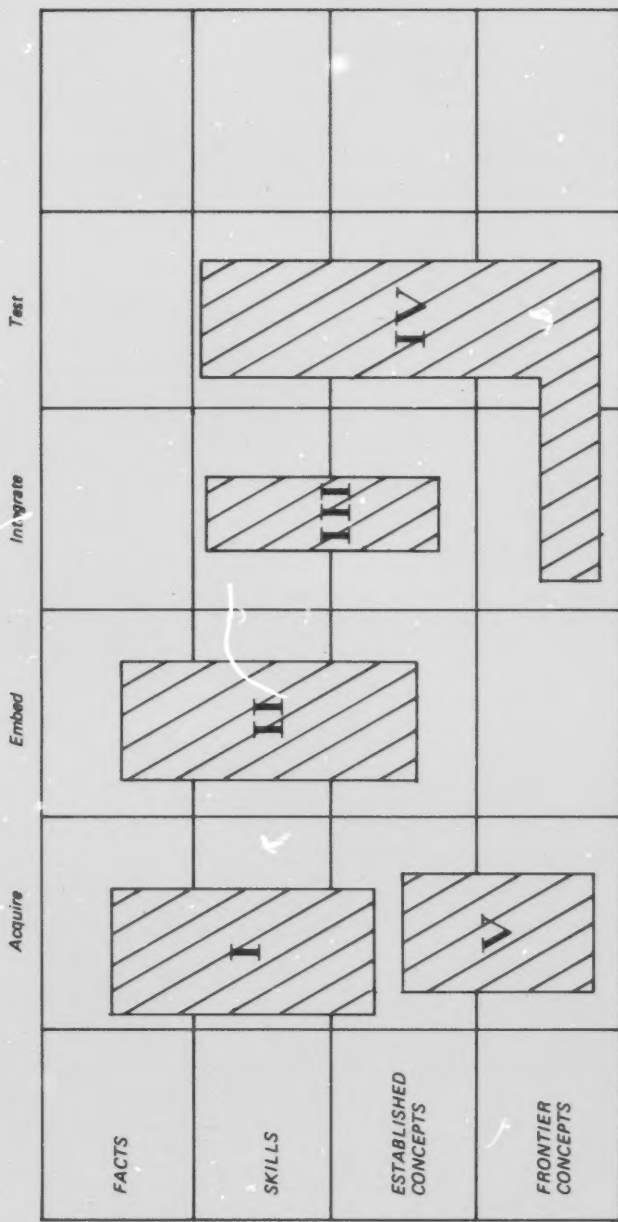
Move now back to the second cell from the left at the top of the matrix. In order to embed facts, the learner needs feedback, as immediately as possible, in order to know how well he or she has performed on answering questions which test whether or not one has acquired the required fact. This is usually done today through homework. Unfortunately, the lag in time from the point at which the student completes homework to the time one receives written feedback from the professor or teaching assistant is often quite long. It is also desirable for the learner to control the homework process. The learner, for example, might omit imbedding exercises on material previously learned. Under current paper and pencil methods, this is difficult to do since the learner usually is required to perform all of the exercises given. A computer-based drill and practice interactive system in which the student is tested, allowed to answer, and given immediate feedback on the correctness of an answer, is much the preferable mechanism in this cell. With continuing decreases in computer costs, in the relatively near future the computer can become the mechanism of choice for embedding facts, skills, and so on.

This discussion of "matching" appropriate learning aids to the need of each cell can be generalized somewhat to develop *groups of cells* which will benefit from the same general treatment. Figure 7 suggests this generalization. Five distinct areas are shown. Area I learning is effectively facilitated by the textbook. Area II best uses either paper homework exercises or computer drill and practice as learning aids. Area III is best assisted by computer-based drill and practice or computer-based problem-solving methods. The area shown as IV is best assisted through computer simulation or games as the arguments suggested for the lower right hand corner of Figure 6 have noted. Finally the area marked as V is the province of the professor.

Where some of the cells are overlapped by two or more general areas of learning assistance or left blank, multiple learning aids are possible.

SUMMARY AND IMPLICATIONS

In this chapter a generalized model which matches varying learning aids to the needs of the learning process has been presented. This two variable, 16 cell model of the learning process has been useful in the design



Key: I Textbook; II Paper or Computer; III Drill and Practice or Problem Solving (Computerized); IV Computer Simulation, Games; V Professor.

Figure 7. Attribute Groupings by Stages in the Learning Process

of courses and in the choice of learning aids to assist students in comprehending varying types of material at varying stages of the learning process. (8) The model suggests places where the computer dominates as a learning aid. Perhaps more importantly, it also suggests places where other learning resources dominate in the learning process.

The model presents, therefore, an explicit recommendation of the types of computer-based learning assistance which should be allocated funds from increasingly scarce higher education dollars. It further suggests that the computer-based tutorial instruction (better known as Skinnerian-type programmed instruction) which is usually used for the transmission of facts should not be a priority area for the allocation of funds at the present time. (There are, of course, exceptions to this rule. One is in cases of an exceptional need to motivate students, such as in the case of retarded students, or the need to rapidly assimilate particular vocabularies.) In general, however, computer-based tutorial methods suffer greatly by comparison with traditional textbooks for the acquisition of facts. The model is therefore in conflict with much of today's government funding of computer-based learning aids.

However, a survey of computer use to aid learning in higher education in the state of Massachusetts suggests that where professors are voting with their institutions' own dollars, they are in heavy agreement with what the model suggests. (9, Chapter 7) There are virtually *no* tutorial programs being utilized which were developed through non-government funds in Massachusetts. Rather money is being spent to support computer-based aids to *embed* (drill and practice programs) material, *integrate* material, and allow students to *test* ideas in simulated or gameed environments.

An explicit statement of the learning model that underlines the use of computer systems to aid education is useful alone. It is helpful, even if one never touches a computer for the insights it provides into learning and, therefore, teaching. On the other hand, it can be even more helpful in specifying the correct tools to assist learning and particularly in allocating increasingly scarce higher education dollars toward areas where the computer can be of the most help in assisting the learning process.

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Chapter 11

COGNITIVE STYLE AND THE COMPUTER*

by Robert Doktor

The concept of the two cultures defined by C.P. Snow is familiar to many. One culture is logical and analytic while the second culture is more holistic and global. The first culture is concerned with symbols as the vocabulary of thought, and the second culture deals in pictures and forms and body movement as vocabulary. Most scientists, mathematicians, wordsmiths are members of the first culture; most artists, craftsmen, and dancers are members of the second culture.

Research on cognitive style indicates that there are two cultures within everyone. Psychologists have identified two global modes of information processing and demonstrated that both modes exist in almost all people concomitantly. The psychologist calls these modes of information processing cognitive style.

The first cognitive style which parallels C.P. Snow's first culture, is characterized by words like analytic, sequential, linear, verbal-symbolic, field independent, sharpener, and converger. The second cognitive style is characterized by words like intuitive, heuristic, non-linear, global, wholistic, pictorial, spatial, leveling, and divergent.

This paper is intended to bring each reader to a fuller appreciation of the characteristics of these cognitive styles.

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CEREBRAL COGNITIVE SPECIALIZATION

In what follows, the author has drawn heavily on the work of Robert Ornstein and his colleagues.

The cerebral cortex of the brain is divided into two hemispheres, joined by a large bundle of interconnecting fibers called the "corpus callosum." The left side of the body is mainly controlled by the right side of the cortex, and the right side of the body by the left side of the cortex.

Although each hemisphere shares the potential for many functions, and both sides of the cortex have been shown to participate in most activities, in the normal person the two hemispheres tend to specialize. The left hemisphere, which controls the right side of the body, is predominantly involved in logical analysis especially in verbal and mathematical symbols and appears to process information sequentially. The first cognitive style resides here. The right hemisphere appears to specialize in holistic thinking characterized by the term intuitive synthesis. Verbal ability here is quite limited. This side of the brain is primarily responsible for one's orientation in space, artistic endeavor, crafts, body image, recognition of faces.

Right-left specialization is most apparent in righthanded persons. Left-handers, who are about 5% of the population, are less consistent; some have reversed specialization of the hemispheres, and some mix their specialization and have, for example, language abilities in both hemispheres. It is interesting to note that in young children, both sides of the cortex seem capable of either area of cognitive specialization. In fact, a young child who suffers brain damage in the left hemisphere often develops language abilities in the right hemisphere.

What is the evidence for these provocative statements which seem to geographically pinpoint cognitive functioning? For more than 100 years neurological evidence has been gathering. For example, valuable evidence has come from the study of people whose brains have been damaged by accident and, more important, from the results of surgery performed upon them. An excellent review of research on this topic is available.⁽¹⁾ Scientists at McGill University report that right temporal lobectomy severely impairs performance of visual and tactile images, whereas left temporal lobe lesions of equal extent produce no significant visual or tactile deficit. Further, the McGill team reports that lesions in specific areas of the left hemisphere are associated with certain kinds of language difficulties. Verbal memory loss is associated with lesions to the left temporal lobe. Musical pitch recognition has been associated, by the McGill group, with the right hemisphere.

Even more interesting is the research of Roger Sperry of the California Institute of Technology, and his associates with human patients treated for severe epilepsy by severing of the interconnections between the two cerebral hemispheres, effectively isolating one side from the other. The

hope of this surgery was that when a patient had a seizure in one hemisphere, the other would still be available to take control of the body and ingest the proper medication or inform the doctor of his attack. In day-to-day living, these "split-brain" people exhibit almost no abnormality. However, Roger Sperry and his associates have developed many subtle tests which uncovered evidence that the operation had clearly separated the specialized functions of the two cerebral hemispheres.

If a patient felt a pencil (hidden from sight) in his right hand, he could verbally describe it, as would be normal. But if the pencil was in his left hand, he could not describe it at all. Recall that the left hand informs the right hemisphere, which does not possess any capability for speech. With the corpus callosum cut, the verbal (left) hemisphere is no longer connected to the right hemisphere, so the verbal apparatus literally does not know what is in the left hand. If, however, the patient was offered a selection of objects such as a key, book, or pencil, and was asked to choose the previously given object with the left hand, he or she could choose correctly, but could not state verbally just what he or she was doing.

Another experiment tested the lateral specialization of the two hemispheres using visual input. The right half of each eye sends its messages to the right hemisphere, the left half to the left hemisphere. In this experiment the word "heart" was flashed to the patient, with the "he" to the left of the eyes' fixation point, and "art" to the right. Normally if a person were asked to report this experience, one would say that one saw "heart." But the split-brain patients responded differently, depending on which hemisphere was responding. When the patient was asked to *name* the word just presented, he or she replied "art," since this was the portion projected to the left hemisphere, which was answering the question. When, however, the patient was asked to point with the left hand to one of two cards on which were written "he" and "art," the left hand pointed to "he." The simultaneous experiences of each hemisphere seemed unique and independent of each other in these patients. The verbal hemisphere gave one answer, the nonverbal hemisphere another.

Although most righthanded people write and draw with the right hand, most can to some extent write and draw with their left. After surgery, Dr. Bogen tested the ability of the split-brain patients to write and draw with either hand. The ability to write English remained in the right hand after surgery, but this hand could no longer draw very well. It seemed to have lost its ability to work in a relational, spatial manner. Given a square to copy with the right hand, the patient might draw four corners stacked together: he or she could draw *only* the corners; the hand seemed no longer able to link the disconnected segments. The left hemisphere, which controls the right hand, seems to be able to operate well in an analytic manner, yet poorly in a relational mode. In these patients, the performance of the left hand reversed that of the right. The left could draw and copy spatial figures, but could not copy a written word. In the

split-brain patients, the right hemisphere can understand some simple speech, though it has no capacity for verbal expression. Dr. Sperry's research has not yet indicated whether this is an artifact of the surgery or whether it represents a rudimentary right-hemisphere capability in normal people.

Split-brain surgery most dramatically delineates the two major modes of cognitive style which seem normally to coexist within each person. One experiment with the split-brain people has also indicated that their two hemispheres can simultaneously process more information than can those of a normal person. Dr. Sperry writes of the effect of the operation in humans: "Everything we have seen so far indicated that the surgery has left each of these people with two separate minds, that is, with two separate spheres of consciousness. . ."(4).

Recent research with normal people has confirmed much of the neurosurgical explorations completed on brain-injured subjects.

If the right hemisphere operates predominately in a simultaneous manner, it could integrate diverse input quickly. This mode of information-processing would be advantageous for spatial orientation, when the person must quickly integrate visual, muscular, and kinesthetic cues. In a carefully controlled experiment with normal people, the right hemisphere was found to be superior in depth perception to the left.(2)

When a tachistoscope is used to introduce information to only the right hemisphere and either a nonverbal or a verbal response is required, the nonverbal response comes more quickly than the verbal one. A verbal response requires the information to be sent across the callosum to the left hemisphere, which takes some time. This indicates that the normal brain does indeed make use of the lateral specialization, selecting the appropriate area for differential information processing.(3)

Another experiment which confirms the differential specialization of the two hemispheres uses eye movements as an indicator. Ask a friend a question such as, "How do you spell Mississippi?" The chances are that he or she will gaze off to one side while reflecting. Marcel Kinsbourne of Duke University, and Katherine Kocel, David Galin, Edward Merrin, and Robert Ornstein of the research group at the Langley Porter Neuropsychiatric Institute, have found that the direction in which a person gazes is affected by the kind of question asked. If the question is verbal-analytical (such as "Divide 144 by 6, and multiply the answer by 7"), more eye-movements are made to the right than if the question involves spatial mentation (such as "Which way does an Indian face on the nickel?").

Kinsbourne has performed another experiment which deserves special mention. Ask a friend to balance a wooden dowel on the index finger of each hand, one hand at a time. Generally, the preferred hand is more adept at this balancing. Ask the person then to speak while balancing this

dowel, and time the length of the balancing. In Kinsbourne's experiment, the balancing time of the right hand decreased, as would be expected, since the addition of a task interferes with performance in most situations. But the balancing time of the left hand increased with concurrent verbalization.

The normal brain constantly exhibits electrical activity, in the form of very low voltages, as recorded at the scalp by the electroencephalograph or EEG. If the EEG is recorded from both hemispheres of a normal person during the performance of verbal or spatial information-processing tasks, different "brain-wave" patterns result. During a verbal task, the alpha rhythm in the right hemisphere increases relative to the left, and in a spatial task the alpha increases in the left hemisphere relative to the right. The appearance of the alpha rhythm indicates a "turning off" of information processing in the area involved. As if to reduce the interference between the two conflicting modes of operation of its two cerebral hemispheres, the brain tends to turn off its unused side in a given situation.

NORMAL FUNCTIONING AND COGNITIVE STYLE

But how do these two modes interact in daily life? In most ordinary activities one simply alternates between the two modes, selecting the appropriate one and inhibiting the other. It is not at all clear how this process occurs. Do the two systems work continuously in parallel, and merely alternate control of the body, or do they truly time-share the control? Clearly everyone can work in both modes. The two modes of operation complement each other, but do not readily substitute for one another.

Within each person the two polarities seem to exist simultaneously as two semi-independent information-processing units with different specialties. There is some evidence that the modes of physiological organization may be different in the two hemispheres. Josephine Semmes, of the National Institute of Mental Health, has found that damage to the left hemisphere results in quite localized disturbance of function, whereas damage to the right interferes less focally with performance. Semmes and her co-workers studied 124 war veterans who had incurred brain injuries. Evidence seems to indicate that the left hemisphere is more anatomically specialized for the discrete, focal information-processing underlying logic, and that the right hemisphere is more diffusely organized, which is advantageous for orientation in space and for other situations which require simultaneous processing of many inputs.

It is the polarity and the integration of these two modes of cognitive style, the complementary workings of the analytic and the intuitive, which underlie civilization's highest achievements. However, it has often been noticed that some persons habitually prefer one mode over the other. The

exclusively verbal, logical scientist manifests a dominance, and may often forget and even deny another side; he or she may find it difficult to work in the areas of the right hemisphere, in art, crafts, dance, sports. But this other mode, although less logical and clear, is important for creativity.

Demands of environment, in particular, ones work or occupational environment, bombards an individual with tasks which are, by their very nature, more easily and effectively coped with through logic and the analytic left hemisphere style of information processing rather than ones second cognitive style. Thus it is a Darwinian mechanism which tends to push most people to give predominance to processing information in the cognitive style of the left hemisphere. Others, who are in Snow's second culture, function predominately with their right hemisphere when processing information. Their cognitive style is holistic, intuitive and non-verbal.

TAILORING COMPUTER USE TO COGNITIVE STYLE

What are the questions raised for the use of the computer in education by the existence of two cognitive styles and the apparent divergence between individuals with differing predominate modes of information processing? At least five categories of questions are apparent.

- Interaction between the various modes of CAI and individual cognitive style predominances.
- Introduction of predominately intuitive and holistic right hemisphere faculty to the use of CAI which has been developed primarily by the left hemisphere culture.
- Relation of teaching and learning computer programming to right as well as left hemisphere modes of information processing.
- Difficulties in managing staff in computer centers who may have different cognitive styles of thought.
- Implications for personal growth and development as fully functioning individuals.

In the first category, questions should be addressed to the use of the computer in education and to the different cognitive styles of learners. Of three modes of CAI, tutitional, drill & practice, and simulation, clearly simulation, provides greater opportunity to exercise both types of cognitive style. However, in a different form drill and practice CAI might be useful in right hemisphere education.

Questions in the second category seek to improve interaction between designers of computer aids to education, and the faculty of the departments of the university that are predominately right hemisphere oriented such as art, sculpture, music, or dance. Might faculty with different predominant cognitive styles not only be speaking a different language, but processing the input language differently? Even if one had

an appropriate CAI usage for them, how does one communicate that usage across cognitive style differences?

The third category moves the focus of questions from the university in general into the departments of computer science and the computer center. In teaching programming, faculty may be developing right as well as left hemisphere abilities. The author's research seems to indicate this. If this is so, why not recognize and prosper from it? Programming is treated in most colleges as an exclusively left hemisphere subject. This practice may be more a consequence of our projections than of the character of the subject matter.

Turning to the management of computer centers or, one must recognize that some people are more right hemisphere types than others. Should one manage them differently? Are current policies punishing them for not fitting in when they should be recognized as rare resources?

Finally, everyone must consider the potential of developing both cognitive styles. Are each of us giving in to the demands of our occupational environment too easily? Are we becoming half-people in the service of effective operation within our profession? Should we give more exercise to the right hemisphere? People can function in both cognitive styles and can make the two cognitive styles interact. We can and should consciously attempt this. Many have come to raise the logical analytic on a pedestal over the intuitive synthetic, but unfortunately so. But it is possible to reach ones fullest potential as a student or a professional only if one breaks out of the present unimode of information processing and utilizes both forms of cognitive style.

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Chapter 12

INSTRUCTIONAL USES OF COMPUTERS IN HIGHER EDUCATION: A Survey in Massachusetts*

by Ada Barbara Demb

In the spring of 1974 in conjunction with the larger research project then being conducted by Professors Rockart and Morton, John Reid and I conducted a survey of computer use in colleges in Massachusetts. Prior to this study, the latest comprehensive data available was from two studies conducted in 1969, and 1967 by G.A. Comstock. The 1974 survey was designed to discover the level of current computer use, and the nature of present instructional endeavors.

The survey looked at all colleges in Massachusetts which were four year institutions and which offered a bachelor's or higher degree. In all but five of the 78 such schools we talked personally with instructors and computer staff. Three-quarters of those schools were using computers and more than half used computers in instruction.

Although the distribution of institutions in Massachusetts differs from the national profile suggested by the 1967 data since the state has proportionately more doctoral research institutions, this does not generally affect the usefulness of the data in putting together a picture of current usage. When appropriate in the course of discussion, biases will be noted. Several general questions were examined and trends were identified where possible.

* A detailed description of this research project appears in *Computers and the Learning Process in Higher Education*, by John Rockart and Michael Scott Morton (Carnegie Commission on Higher Education, McGraw-Hill) May 1975, Chapter 7.

COMPUTER USE AND FUNDING PRIORITIES

What is the general level of computer use and how are schools setting priorities with regard to expenditures for research, administration and instruction? Very few general institutions are not making some use of the computer. Since 1969 the smaller general institutions offering a master's degree or less have caught up to the larger institutions in terms of student access to computing resources. In addition to the increase in the use of smaller and cheaper minicomputers, the availability of large-scale computers to smaller groups of users through time-sharing networks and other administrative arrangements has been effective in making this widespread availability possible. In 1967, the national study revealed that only 39 percent of the institutions of higher education in the country were making any use of the computer. In 1974 in Massachusetts the percentage was 75. This data suggests also that further growth will probably not take place by introducing computers into institutions formerly having no computer. Instead, growth will come from new applications and new equipment for institutions already familiar with the technology.

The Overall row in Figure 1 shows a striking decrease in the portion of computer expenditures being allocated to instruction. The column to the far right shows that institutions at every degree level experienced a decrease in the instructional portion of their computer expenditures. Two possible sample biases were explored: 1) the presence of large research institutions in Massachusetts; and 2) the predominance of doctoral institutions who may spend smaller portions of budgets for instruction. In the first instance, Figure 1 illustrates that the portion of the budget allocated for instructional computing has declined for institutions granting degrees at all levels. Regarding the second potential bias, the national survey reported about the same percent of total expenditures coming from doctoral institutions as the 1974 survey found in Massachusetts. The data thus suggest that this decline in research reflects the dramatic decrease in the availability of foundation and federal funding for research and instruction, as well as the increased need for administrative effort which occurred as financial control became increasingly more important during the period 1967 to 1974. Clearly, much greater portions of total institutional budgets at all degree levels are being allocated to administrative applications in 1974.

It should be noted also that in 1966 a report of the National Academy of Sciences (3) found that 20 percent of the total computer expenditures in colleges were being allocated to instruction at that time, and the report predicted that this portion would decrease. Comstock's survey of California indicated that instruction comprised 27 percent of institutional budgets in 1968-69. The 1974 Massachusetts percentage reflects a clear decline.

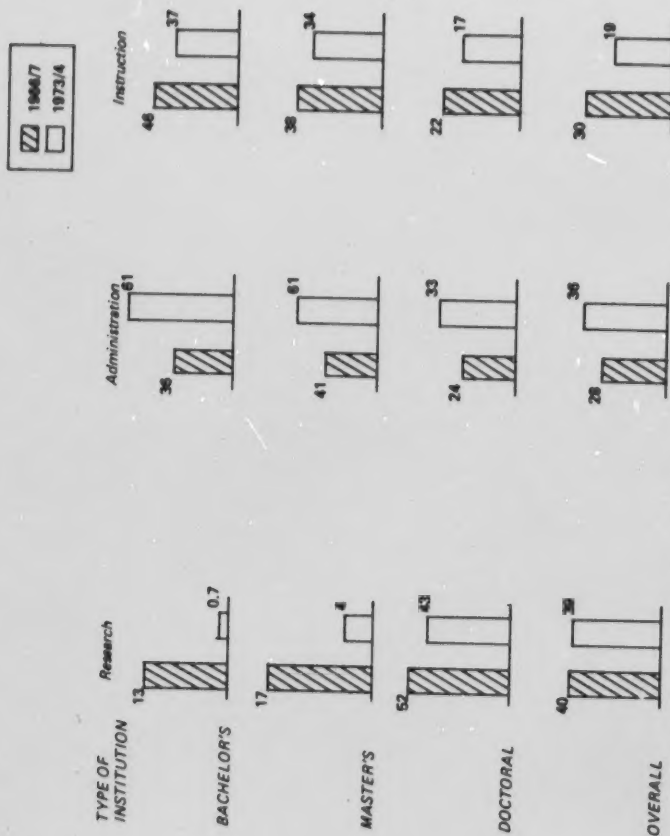


Figure 1. Changes in Allocation of Dollars for Research, Administration, Instruction

What does this decrease in instructional expense mean for academic use? Are there fewer resources available? Although the numbers may appear deceptive, the answer is no. The 1967 report of the President's Science Advisory Committee (4) recommended an average expenditure of \$60 per student for instructional uses of the computer. The 1974 data show that on average the expenditure per student for instructional computer uses in Massachusetts in 1974 was about \$17, apparently far less than the goal of \$60. However, if one takes into account the increase in computer power per dollar of hardware expenditure which has roughly doubled each year and further adjust for inflation, today's \$17 provides much greater computer power than the \$60 per student level requested by PSAC could have provided in 1967.

It is also interesting to note, the numbers of students who make use of the computer. The Massachusetts data suggest that the number of students in courses using the computer nationally has increased four-fold since 1967.*

COMPUTER USE FOR INSTRUCTION

In discussing the use of computer instruction in higher education, it is useful to distinguish between two distinct types of application. The first, instruction "about" the computer, involves the part of the university curriculum that deals with the various aspects of computer technology itself. Computer science courses and programming courses fall in this category as do many other courses. The second application, instruction "with" the computer, involves use of the computer as an aid to instruction in courses in all disciplines.

In Massachusetts courses about the computer represented 43 percent of instructional expenditures, and courses with the computer represented 57 percent, a clear majority. Earlier studies, which presented only qualitative statements in this area, reported that far more of the total expenditures were devoted to instruction about the computer than to instruction with the computer. However, 1974 data show the reverse to be true now. In fact, the financial figures understate the shift to instruction with the computer. Of all courses using the computer, about 70 percent are classified as instruction with the computer.

The discrepancy between the percentage of expenditure and the percentage of courses with respect to courses about the computer represents the nature of the programming involved. Courses of instruction about the computer generally involve simple program debugging at a continuous, high rate over the course of a semester.

* Such extrapolations are based on Massachusetts student population as 4% of national, and institutional population as 3%.

In the survey of the colleges in Massachusetts, each institution was asked to provide a list of courses using the computer which was then categorized into five areas:

- *tutorial*, CAI, programmed instruction, etc.
- *drill and practice*, using the computer to try out or to become more skilled at concepts and techniques learned from another source
- *problem-solving*, using the computer as a calculator or data analyzer
- *simulation and games*, constructing models to gain insight about real-world phenomenon, and/or using these models for competition (These were separate categories in the original report.)
- *inquiry/retrieval*, accessing data bases.

As is shown in Figure 2, the primary use of the computer is in problem-solving, followed by drill and practice and then simulations/games. Only three cases of tutorial were found; two as remedial instruction, and one which prepared students for a state licensing exam. Also the survey noted only two instances of inquiry/retrieval from a total of 1200 courses. As can be seen from the graph, drill and practice, problem-solving, games and simulations comprise 96 percent of all use of the computer as an instructional aid in the Massachusetts colleges surveyed.

PRINCIPAL USERS

Figure 3 shows relative use of computers as aids to instruction by academic field. Because the graph shows use as a percent of courses with computer aid, computer science does not appear.

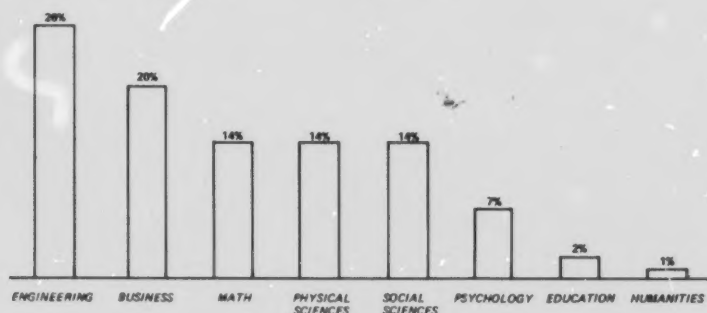


Figure 3. Computer Use by Academic Field as Percent of Total Courses with Computer Aid Instruction

Engineering is the major user, followed by business, mathematics and the physical and social sciences. The ordering of disciplines has not changed during the past several years, although the magnitude of use in

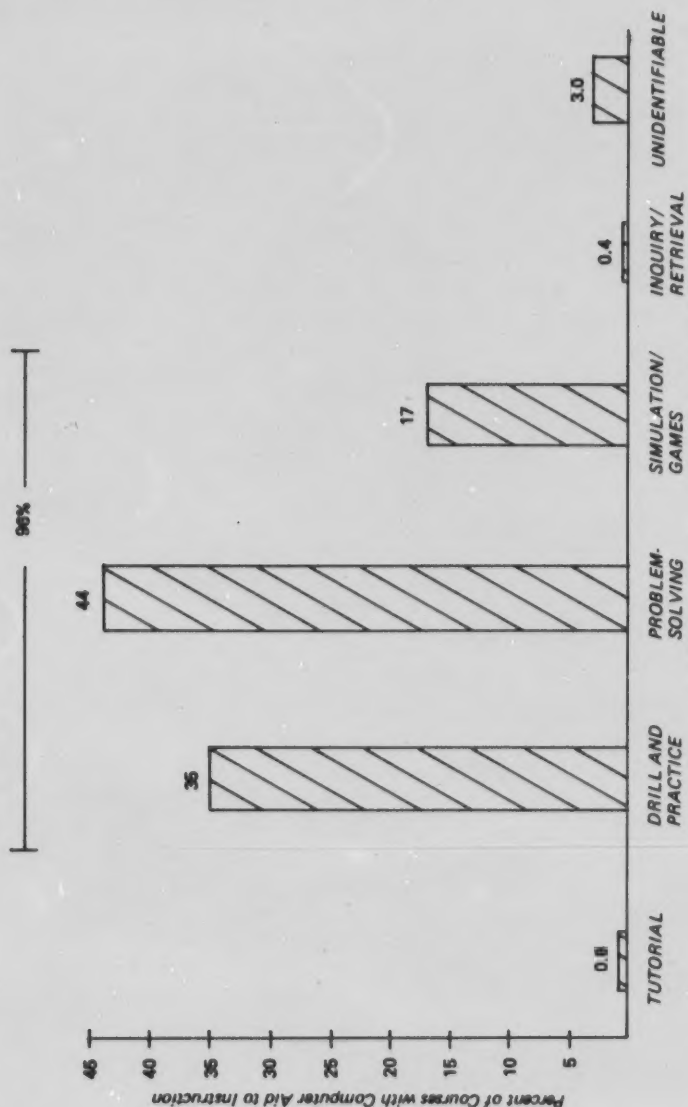


Figure 2. Type of Computer Use as a Percent of all Courses with Computer Aid to Instruction

certain disciplines, particularly business, the social sciences, psychology and education has increased significantly.

The percent of students in the fields has shifted somewhat, however. As Table 1 illustrates, the greatest shift has occurred in engineering, computer science, business and mathematics. The decrease in numbers of engineering students reflects the absolute decline in engineering enrollments during the past several years. In business the increase is due both to increases in enrollment in this field and dramatic new developments in computer applications.

Table 1
Shifts in Distribution of Students and Student Costs

<i>FIELD</i>	<i>% Students</i>		<i>Average Cost/Student</i>	
	<i>1967</i>	<i>1974</i>	<i>1967</i>	<i>1974</i>
Engineering	35	17	52	113
Computer Science	22	9	81	195
Business	23	34	60	36
Mathematics	4	12	252	93
Physical Sciences	5	8	109	49
Social Sciences	3	9	69	43
Psychology	1.5	2	126	15
Education	2	1	91	26
Humanities	0.4	0.2	92	99

There has also been a relative decline in the number of courses offered in computer science. However, even though computer science has relatively fewer students, its proportion of the total instructional budget has remained constant suggesting that the new applications being utilized in business and social science courses tend to be less expensive in any given course than do new applications in older computer-utilizing fields such as math and computer science. This hypothesis is confirmed by the data in the third and fourth columns of Table 1 which shows the average expenditure per student for each academic field, 1973-74, compared with the data from a national survey of 1966-67 conducted by the Southern Regional Education Board. Massachusetts 1974 data indicate that cost per student in social science and in psychology is less than half the cost in engineering, mathematics, and computer science. It also indicates a large decrease in cost per student in mathematics relative to computer science and engineering. The decrease in mathematics expenditures may be due in part to reorganization of computer science as a separate department, but it

may also reflect a phenomenon common to all disciplines, increasing student exposure to marginally inexpensive application.

Figure 4 identifies the principal users and types of application. Examining the dispersion of computer applications across academic fields, one finds that drill and practice, and problem-solving both share a universality of sort; almost every field made use of both types of applications. In the social sciences and psychology, drill and practice and problem-solving applications primarily represent use in statistics courses and econometrics.

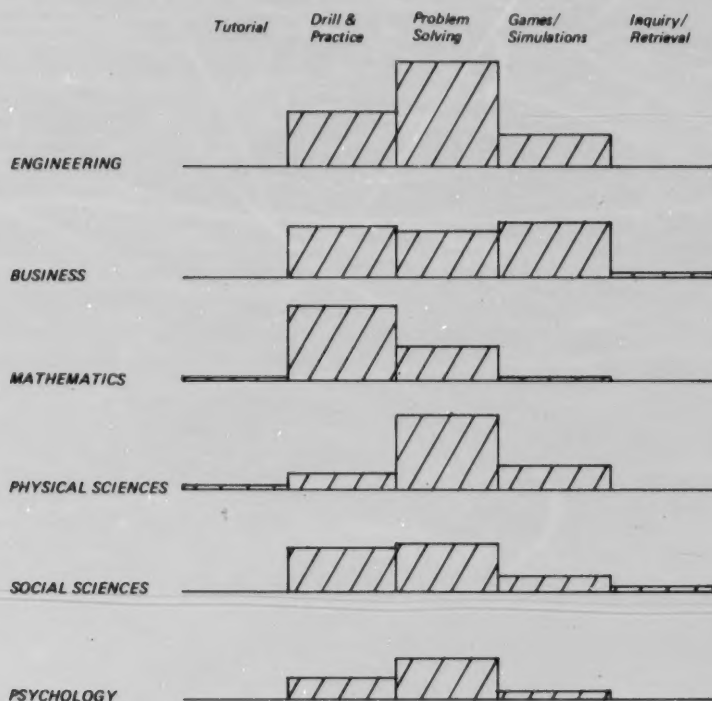


Figure 4. Type of Computer Use by Academic Field

It is also interesting to note the apparent universality of games and simulations. These applications ranged from the very sophisticated business, legal and environmental games/simulations to very practical applications. One school where an electron accelerator was not accessible, developed a simulation of this machine.

Growth in the use of the computer in instruction has been characterized by high activity levels outside of computer science and engineering, with relative declines in use being evident in these latter disciplines. Most students involved in instruction with the computer use it to reinforce concepts, to practice skills (drill and practice), and as an aid in problem-solving. These applications are evident in almost all disciplines using the computer.

CONCLUSION

The institutions surveyed in Massachusetts in 1974 represent a small, non-random sample of American colleges and universities. Extrapolating from this sample to a description of all four-year institutions in the United States is a considerable jump and tempers the absolute accuracy of the data. However, with this in mind four major trends are evident:

High Growth. Use of the computer in higher education has grown rapidly over the past seven years, with administrative uses of the computer growing fastest of all. Nationally a conservative estimate of this seven-year growth is an annual rate of about 16 percent. In instruction, the number of students who are being exposed to the computer through courses has grown during the same period at a rate more than 20 percent per year. Allowing for inflation, but adjusting for the increase in computer power per dollar, it is clear that significantly more computer power is being devoted to instruction both with and about the computer in 1974 than in 1967.

More Teaching With the Computer. The percentage of computer-using courses teaching with the computer is estimated to be about 70 to 75 percent of the total number of courses using computers. There is an evident swing from the use of computers primarily as a tool to teach about the computer to teaching with it.

Greater Dispersion of Courses across Academic Fields. In particular, physical sciences, social sciences, business, and mathematics have increased their share of the use of computers for instruction.

Bulk of Application: Drill and Practice, Problem-Solving, Games/Simulations. Each of these applications was found in most of the departments reporting use of the computer. By contrast, there were very few instances of tutorial or inquiry/retrieval uses.

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Chapter 13

THE FEAR IS GONE: A Study of the Adoption of Computer-Based Curricula in North Carolina's Institute for Undergraduate Curricular Reform

by Joseph R. Denk

INTRODUCTION

The 1973 Institute for Undergraduate Curricular Reform (1973 IUCR) in North Carolina was dedicated entirely to computer-based instruction. Sponsored by the University of North Carolina and designed by seven faculty teams made up of experts from several institutions, the 1973 IUCR became a formal study of the adoption of computer-based curricula. Open to all faculty from all senior institutions in North Carolina, eight summer workshop programs involved a test population of 136 teaching faculty in biology, business, chemistry, economics, music composition, political science, psychology, and sociology. A ninth workshop for training administrators in decision-making for instructional facilities brought the personnel involved to a total of 245 from 42 of the 45 senior institutions in North Carolina.

The 1973 IUCR inherited four years of a State-wide curriculum development project run by the network in North Carolina, NCECS. A further enhancement was the first year of CONDUIT as implemented in NCECS. This formal test of transportability added a new level of materials

and approaches. This history included over 40 2-day workshops for exposing curriculum materials. What the 1973 IUCR added to this experience were quantitative techniques, the lack of which was considered to be a major cause for non-adoption and curriculum change in the past. A necessary condition for training in these techniques was added: an increase in workshop time to two to three weeks.

Adoption of materials and approaches for the classroom by the test population increased from 46 to 70 percent as a result of the 1973 IUCR. There were no significant correlations between the adoption and the environment in times of institutional size, age of adopter, status of adopter, State support, or facilities (among other variables). Indications are that the materials and approaches were compelling enough to make them attractive to a wide variety of faculty. These results support the hypothesis that available computer-based curricular approaches are acceptable and within the grasp of most faculty, regardless of age or environment, given minimum substantive, pedagogical, and practical training.

DESIGN OF THE INSTITUTE

The 1973 IUCR gave North Carolina an opportunity to involve faculty from all of the State's senior institutions in specific training for "Quantitative and Computing Techniques in the Undergraduate Curriculum." This second year of a three year program which has been aimed at overall curricular reform allowed the support of 245 participants and leaders in nine programs aimed at computer-based curricular reform.* More specifically, the institute provided an opportunity for a formal study of computer-based (CB) curricula, its materials and approaches. Enough of the complex problems behind initiating CB reform had been attacked in previous efforts in N.C. to guarantee at least a knowledge of the major factors involved.

Of the 45 senior institutions in N.C. higher education, over half of these institutions had been involved in a network sharing a computer.** This network, the North Carolina Education Computing Service (NCECS), had been in existence since 1967 and had been an NSF-supported curriculum development project since 1969. Over 40 two-day workshops involving

* The Second Year of The Institute for Undergraduate Curricular Reform in North Carolina was funded by the National Endowment for Humanities, the National Science Foundation, the Smith Reynolds Foundation, the Smith-Richardson Foundation, and the University of North Carolina.

** The IBM 370 Model 165 of the Triangle Universities Computation Center. A network (the North Carolina Educational Computing Service) of 60 institutions (including 21 senior-institutions) uses this center along with the three owning Universities — Duke, North Carolina at Chapel Hill, and North Carolina State.

2300 faculty participants had exposed a leader population. The basis for these material-exposition workshops had been some 3600 curricular packages gathered by NCECS. (16) Further, NCECS had already benefitted from the first year of CONDUIT and its work toward transportability. (6) With this background touching every senior institution in the State, regardless of network involvement, a basis for a formal study seemed feasible.

The 1973 IUCR provided the resources to formally study CB materials and approaches. In addition, with a longer training time (two weeks as compared to two days) it was possible to add training in quantitative techniques to the exposition of materials. The participants in the earlier 2-day network workshops indicated that the absence of these techniques prevented adoption of CB techniques. Since these techniques necessarily come from discipline-based experts, the 1973 IUCR could be viewed as testing the hypothesis that the addition of these techniques in longer workshops could enhance adoption.

In order to test this hypothesis, faculty teams were used to entirely design and run the programs of the 1973 IUCR. These teams were selected from both network and non-network experts in hopes of preserving unbiased critical design conditions. No personnel directly involved with computer center operations were placed on any team.

General constraints in the study included the selection of the discipline topics and the target population. Eight discipline areas were predetermined from the interests of the funding agencies and under a concerted attempt to eliminate those disciplines which already had significant development (e.g. physics and engineering). The faculty population was chosen with a first priority given to maximizing the number of institutions involved.

In addition the selection of faculty participants was constructed so that the participation of faculty would be approved by the institution. Invitations were sent first to college presidents, then to departmental chairmen, and finally to individuals. All applications requested the signature of a chairman along with that of the applicant.

Two factors considered to inhibit the growth of CB instruction were considerations behind this scheme of obtaining participants. First, lack of institutional approval of faculty activity could provoke at least financial barriers. Second, lack of institutional awareness of computer resources could leave faculty with no way to implement techniques. A ninth workshop for administrators was run in the Institute as another partial solution to the second problem.

Seven faculty committees with a total of 42 members designed the nine summer programs. Committees were selected in an attempt to represent both the public and private sectors, the entire spectrum of institutional size, and both the network and non-network environments. These committees were assigned the selection of materials, the design of the

workshops, the selection of the teaching teams, and the establishment of any prerequisites for participation. In addition, the teams gave final approval on applicants.

THE INSTITUTE AND THE PARTICIPANTS

A summary of the programs involved in the 1973 IUCR is given in Table 1.

Table 1
Summary of the Summer Programs of the 1973 IUCR

<i>Program</i>	<i>Length (weeks)</i>	<i>Number of Participants and Leaders</i>	<i>Number of Institutions</i>
BIOLOGY	2	33	20
BUSINESS	2	22	21
CHEMISTRY	2	35	11
ECONOMICS	2	22	15
MUSIC COMPOSITION	2	14	9
POLITICAL SCIENCE	3	29	16
PSYCHOLOGY	1	14	11
SOCIOLOGY	3	37	21
ADMINISTRATOR'S	(3 days)	75	28

Each of the discipline programs had as general objectives: communication of the substance of the materials selected; training in the use of these materials; training in the quantitative (and computing) techniques necessary for support of these materials; and the providing aid in the design of individualized pedagogy for implementation. Each program emphasized general objectives.

Biology (Environmental Sciences). Designed for beginners, this program concentrated on the exposure of over 50 small modules for topical treatment in several possible courses. The topical treatments were supported by training sessions in programming, statistics, and curve fitting.

Chemistry. Under the assumption of a limited background in computer usage by the participants, concentration was placed on larger and more complex modules than in the biology program. Quantitative techniques included numerical methods, statistics, curve fitting, and remedial programming. Chemistry and biology were run at the same time in parallel sessions with some common treatment.

Business. The large course segments required to treat the games and modules available for business resulted in a concentration on game management and understanding. Quantitative methods included statistics, regression, linear programming, and computer programming.

Economics. Heavy emphasis was placed on modelling theory along with pedagogical implementation. Statistics and empirical approaches were added to the treatment of several models.

Music Composition. This boiled down to the training in the usage of one large composition package — MUSIC 360.

Political Science. Run in parallel with the sociology program, this session concentrated on survey analysis and simulation with a heavy dose of statistics. Quantitative techniques in common with sociology sessions involved the practical skills of getting data on the computer and subsequent analysis. The group split between statistics and simulation theory.

Sociology Practical skills and pedagogy were the principle thrusts. Getting one's own data on the computer and usable with independence was a primary goal.

Psychology. This program was designed to train faculty in the use of EXPERSIM, a generalized experimental design package.

In general, the nature of the programs is best seen by the materials involved (see following section). The political science, sociology, and business programs could be characterized as having been closer to the goal of producing pedagogical design results in the participants than were the other programs. Biology, chemistry, and economics had more expository approaches than creative design sessions. Music composition and Psychology aimed at direct adoption.

A total of 245 personnel were involved, 226 being participants and leaders. These represented 42 of the 45 senior institutions in N.C. Leaders were almost as numerous as participants since the instruction was modular and under the coordination of only one principal leader for each workshop. Subtracting the 75 participants and leaders who were administrators and 34 additional personnel who were not teaching in 1973-74 in N.C. institutions, the resulting sample size of the classroom test population reduces to 136 from 37 institutions.

Of this test population of 136, over 2/3 never used the computer in the classroom before the 1973 IUCR. Over 1/2 had never written computer programs; 78.8 percent had Ph.D.'s and 53 percent were associate professor or above. The average participant/leader was 38 years old and got his degree 12 years before. Participation was not dominated by larger schools, the average number of individuals in the 1973 IUCR from each institution being unrelated to the enrollment at the institution.

It can be said that the 1973 IUCR got the older faculty — the ones they say are almost untrainable.

A rather large interim report of the 1973 IUCR was published in 1974.(5)

THE COMPUTER-BASED CURRICULUM MATERIALS AND APPROACHES USED IN THE 1973 IUCR

The materials selected represented what the committees considered to be representative of the state of the art. Since each of the committees had representation from inside and outside the network, the material selection was not limited to network holdings. This freedom also extended to the quantitative techniques selected.

The computer used in each of the programs of the 1973 IUCR was the TUCC IBM 370/165. From this limitation, it would seem that several approaches could have been passed up. Several modules from other environments were made available for the workshops but these were always small modules which involved trivial transportability problems.

Five categories of computer usage can be conveniently used to describe the CB approaches involved in all of the eight discipline-oriented programs of the 1973 IUCR. While this approach is always too simplistic, it does offer the only possibilities for comparison of different disciplines, the reason for its adoption. The categories are:

- *MODULES oriented to Course Topics.* From single to multiple topics without integration.
- *INTEGRATED COURSES.* One or more courses for a discipline.
- *SYSTEMS SUBSETS.* One or more implementations of complex approaches as a subset of a super system.
- *INFORMATION RETRIEVAL.* One or more large data bases oriented to some retrieval system.
- *SIMULATIONS.* From simple to complex models.

An example of a MODULE would be a program (and accompanying courseware) that allows data reduction for an experiment in chemical equilibria. Much of the earlier CB curriculum products were of this nature. Some compendia of these modules have reached commercial success and this level represents the top of the line for this category.

INTEGRATED COURSES are a rarity but as such allow inter-disciplinary comparisons. SYSTEMS SUBSETS are modules which have foundations in such systems as super statistical packages (SPSS etc.) or modelling systems (Econometric Software Package). INFORMATION RETRIEVAL needs no examples.

The SIMULATIONS area is separated from MODULES because each simulation, no matter how small, is multi-topical. This complication requires substantially different approaches. Simulations can be run in a one-hour period or over a year.

A brief list of the major materials involved in each workshop will connect these categories with reality.

Table 2
Major Materials Used in Each Workshop

	<i>Materials</i>	<i>Brief Description</i>
BIOLOGY	IOWA ¹⁸	Compendium of 50 MODULES and SIMULATIONS for introductory biology.
	NCECS Materials CLUSTER SYMAP	12 MODULES and SIMULATIONS MODULES for Cluster Analysis SYSTEM SUBSETS of General Purpose Mapping Package, SYMAP.
	CLEANAIR SAS	Air Pollution Strategy Simulation Statistical Analysis System
	BIOLOGICAL ABSTRACTS	INFORMATION RETRIEVAL
CHEMISTRY	JOHNSON ¹²	Compendium of 24 MODULES on Chemistry Topics
	NCECS Library	Over 200 MODULES AND SIMULATIONS for chemistry.
	ISIS ⁷	Infrared (DOW-ASTM) File - (SUPERSYSTEM SUBSET)
	NIH-MASS	Mass Spectrometry - Files of the National Institute of Health
	CHEMICAL ABSTRACTS	Information Retrieval
BUSINESS	CLEANAIR	Air Pollution Strategy Simulations
	WHYBARK ¹	Operations Management-Compendium of MODULES and SIMULATIONS.
	HARRIS ⁹	Operations Management-Compendium of MODULES and SIMULATIONS.
	TEXG ¹⁰	"The Executive Game" - a business game.
	LERNER ¹³	Finance MODULES and SIMULATIONS.
	MLR, MPS	SUBSETS of Multiple Linear Regression and Mathematical Programming System.
	FORECASTING, TRANSPORTATION	Local MODULES
ECONOMICS	Business Games	See Business Above
	ESP ¹⁷	Econometric Software Package
	Empirical Macroeconomics ¹¹	Data Analysis with SPSS
	MACWHARTON ² and Other Macro Models	Macroeconomic SIMULATIONS.
MUSIC COMP	STAT 100	Statistics Package
	MUSIC 360 ¹⁸	Composition Package
PSYCHOLOGY	EXPERTSIM ¹⁴	SUPER-SYSTEM and MODULAR SUBSETS on Experimental Design

Table 2 (Cont.)

POLITICAL SCIENCE	CLUG ⁸	Community Land Use Game, a SIM- ULATION
	PRINCE ⁴	SIMULATION Packages in
	INS ³	International Relations
	Data Analysis	See Sociology below.
SOCIOLOGY	SPSS ¹⁵	Statistical Package of the Social Sci- ences
	IOWA KITS	Nine SPSS "kits" for survey analysis with SPSS
	SIMULATIONS	Four small simulations on small groups and demography
	Data Bases	Several data bases as units of study.

Table 3 attempts to draw a comparison on the CB materials involved across the eight discipline programs. The disciplines are ranked low, medium, and high on all categories as an approximation.

Table 3
Categorical Comparison on the Eight IUCR
Programs on Computer-Based Materials

PROGRAM	Category				
	Modules	Int Courses	Super System	IR	SIMS
BIOLOGY	Medium	Low		Low	Low
CHEMISTRY	Medium	Low	Low	Medium	Medium
BUSINESS	Low	Medium	High	Low	High
ECONOMICS	Medium	Low	High	Medium	High
MUSIC					
PSYCHOLOGY				High	Medium
POLITICAL SCIENCE			High	High	Low
SOCIOLOGY	Medium		High	High	Low

EVALUATION AND RESULTS

Each of the eight discipline programs was followed-up by a two-day meeting during the 1973-74 academic year. Further, a final survey on adoption of CB instruction was made in the Spring of 1974. The data analyses in this section represent these follow-up and final survey activities and their data linked to the earlier data taken before and after the workshop programs themselves.*

* The Human Resources Research Organization (HumRRO) evaluated the summer programs both as to pre- and post-workshop attitudes and as to the materials. These data and analyses are contained in the interim report on the 1973 IUCR. (3)

Of the total of 136 participants and leaders eligible (teaching in N.C. higher education during 1974) to be included in this final analysis 119 (87.8 percent) answered the complex final survey. The 17 non-respondents proved to be split one third-two thirds in experienced vs inexperienced users of the computer. On this basis, their elimination to a final sample size of 119 did not seem to bias the sample unduly.

The analysis of the resulting data is based on measures of adoption of the variety of materials, and/or techniques involved. Of the 119 total, 76 (70.4 percent) said they used the computer in at least one course during 1973-74. This large adoption percentage (compared to the estimated 15 percent resulting from the two-day network workshops) must be seen in terms of the categories of adoption that were used for the measure:

- adopting materials
- modifying materials to specific needs
- adopting approaches
- designing computer-based courses
- creating new materials

These categories show that the 70.4 percent adoption cannot be seen as outright adoption of materials. Adoption merely means that the computer was involved in some way in the classroom.

Table 4 shows how this adoption looked for each of the eight discipline workshops. Table 5 summarizes the frequencies of the categorical activities for the population as a whole. With the mix of categories making up what is proposed as an adoption percentage, it is easy to either inflate or underestimate involvement.

Table 4
Adoption of CB Approaches in Classroom
for the Various Disciplines
(13 Missing Observations)

WORKSHOP	No. Adopting in 1 or more classes	Percentage Adoption
BIOLOGY	9/12	75
CHEMISTRY	9/17	53
BUSINESS	12/15	80
ECONOMICS	8/10	80
MUSIC	4/6	67
PSYCHOLOGY	7/9	78
POLITICAL SCIENCE	10/17	59
SOCIOLOGY	15/20	75

Table 5
Usage by Categories for the 1973 IUCR

<i>CATEGORY</i>	<i>Total Number</i>	<i>Percentage</i>
ADOPTING MATERIALS	54	45.4
MODIFYING MATERIALS	21	17.6
ADOPTING APPROACHES	37	31.1
DESIGNING COURSES	30	25.2
CREATING NEW MATERIALS	37	31.1

Environment did not seem to play a role in adoption. Adoption was unrelated to institutional size as determined by student enrollment ($\gamma = 0.087$). There was also little difference between the adoption in State-supported and private institutions despite the dominance in facilities in State-supported institutions ($\gamma = 0.18$ showing a negligible correlation with State-supported institutions). Even more surprising is the absence of any difference in those adopting for large classes (25 or more) in State versus private institutions ($\gamma = 0.07$). Adoption as well as adoption for large classes were independent of institutional enrollment (γ for both = .088). Small and large institutions (both public and private) were equally interested in adoption no matter how poor the facilities.

It has been an old adage that computer activity belongs to the young. Age made some difference on adoption ($\gamma = -0.35$) but not much. Sex could not be looked at as a factor: Only 18 women were in the sample. Faculty ranking played little importance in adoption ($\gamma = -0.13$) which shows that chairmen and full professors are also involved. Years at the institution also made no difference in adoption rates. These curricular approaches do not seem to be the property of youth.

The respondents indicated that local facilities prevented adoption (32 respondents). More training was called for by 45 respondents in order to achieve adoption. Only 4 were uninterested in adoption. These are strong indications of the quality of the materials and approaches.

The most important test of the materials and approaches would be a measure of increase of usage over that before the 1973 IUCR. Of the 119 faculty, 55 (46 percent) used the computer in the classroom at least once before the Institute. As a result of the institute, 76 said they were using the computer in the classroom — an increase of 38 percent. The old users are holding on as can be seen by the correlation between experience in instructional usage versus adopting ($\gamma = 0.633$). One explanation of the fact that this relation is not even stronger is the surprising absence of a strong relation between experience in instructional usage and adoption for

larger classes — gamma of 0.14. Experience did not seem to be the major factor is going for the large change in the curricula.

Data from IUCR 1973 indicate that fear of the computer in the curriculum is gone. Given a somewhat more intense training by experienced users, users of various ages and experience are attacking large classes with computer-related approaches. Even the variation in facilities did not seem to seriously hamper these results. The encouraging response is even more helpful when it is seen that the old users are not quitting and the new ones are jumping right in.

It is tempting to suggest that the materials and approaches used are of high enough quality to be compelling in themselves. CONDUIT, the network, and formal curriculum development make this temptation larger. Rather, all that can be said is that the role of the computer is desirable and that some minimum mix of training was used to achieve a high rate of adoption.

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Chapter 14

THE COMPUTER AS AN AID IN MEDICAL EDUCATION

by Ruann E. Pengov

INTRODUCTION

The Ohio State University College of Medicine has evolved as a leader in the field of computer applications in medical education. As noted by Kamp and Brigham, (4) over 44% of the available Computer Assisted Instruction (CAI) courseware in medicine and health related areas resides at The Ohio State University. Since the publication of that article, the University of Illinois "CASE" materials have been added to the existing CAI data base in the College, bringing the total to over 50%.

The CAI system at The Ohio State University College of Medicine did not just happen. It has grown from a one-terminal, one-course system in 1967 to the operational system of today, which:

- provides 22 hours per day of continuous service for students and health professionals in Columbus, in Ohio, and throughout the United States.
- maintains a catalog of nearly 200 CAI interactive units.
- logs over 4,000 usage hours/month.
- supports development of new CAI course materials at the rate of two to four student interactive hours per month.

This chapter describes the operational aspects of computer utilization in medical education at The Ohio State University College of Medicine; other volumes discuss research findings and the impact of the usage described

therein. Throughout this discussion emphasis is placed on the *use of the computer*, rather than on the computer itself. Comments focus on:

- arenas of application of CAI (including a discussion of audiences of users)
- configurations for access to CAI
- support environment for CAI usage and development

Most certainly the above categories are not mutually exclusive nor are they intended to address the entire CAI area, they do simply bring some organization to the various subsystems and/or components of the operational CAI System at The Ohio State University College of Medicine.

ARENAS OF APPLICATION OF CAI

At the outset it is imperative to state the philosophy of the College in the development of CAI materials. The emphasis in CAI courseware has been placed on: a) the quality of content; b) the applicability and usefulness of materials in the medical curricula; and c) the soundness of educational strategy. The approach has been to develop an educational resource rather than to emphasize a technology. CAI is an additional tool for utilization by the medical educator. The medium cannot serve all needs, but it can, uniquely, serve *some* needs.

Four major arenas of application of CAI are: 1) undergraduate medical education; 2) continuing medical education; 3) patient education; and 4) non-medical support staff education.

Primary Medical Education

The continuum shown in Figure 1 organizes applications in undergraduate medical education according to: increasing sophistication in the educational strategy; increasing computer system and CAI language sophistication; and progression from a single course concept (generally an individual effort) to the curriculum where coordinated effort by several faculty from varying discipline areas is required.

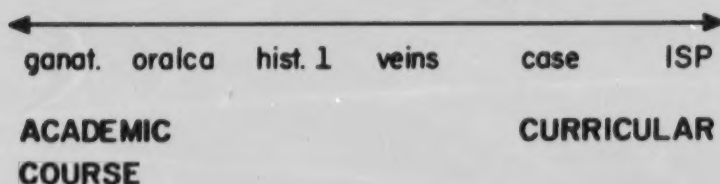


Figure 1. Primary Medical Education – A Continuum of Application

Since 1964, The Ohio State University College of Medicine has been continuously reevaluating and revising its medical education curricula. Initial experience with independent study was acquired through the use of a two track curriculum in anatomy and independent study groups in bio-chemistry.(2) CAI was first utilized in 1967, when CAI courses in anatomy and biochemistry were written to complement the independent study efforts in the classrooms. These courses were used by students as self-evaluation exercises and consisted of essentially multiple choice questions with feedback arranged in a linear sequence (note "ganat" in Figure 1). Under the direction of an oral surgeon, the first case study approach was used in a course on oral cancer recognition (note "oralca" in Figure 1). Number codes were used to interrogate the simulated patient and to subsequently enter a diagnosis. Student controlled slide projectors were used to present color visuals.

Other faculty became interested and, in histology, a simulated laboratory experience at the CAI terminal replaced the actual laboratory in organ identification. Considerable time was saved with similar student comprehension (note "histl" in Figure 1).(8) Appendix C shows a sample student dialogue from the histology course.

Initial efforts in the School of Nursing were CAI courses in basic mathematics review; orthopedic traction and arrhythmia strip interpretation. Faculty concerned with the curricula of medical dietetics, medical records administration, occupational therapy, physical therapy, radiologic technology and respiratory technology in the School of Allied Medical Professions also began to develop CAI courses, some of which are required for student use while others are suggested for review and self-evaluation.

If one progresses to the middle of the continuum of application, the necessity for cooperation and interdisciplinary effort increases. A course on "care and feeding of the veins" was developed with multiple tracks (branches) for the student nurse, nurse, rescue squadsman, student physician and physician (note "veins" in Figure 1).

As CAI courseware development grew more complex, significant additions to the CAI language were required. A course on serum electrolytes and acid base balance required the addition of capabilities for calculation and variable manipulation to the COURSEWRITER CAI language. These enhancements proved essential in implementing a food item nutrient data base (see "foods" in Figure 1) to assist dietitians and student dietitians in menu planning. Building upon "foods", the Division of Dietetics in the School of Allied Medical Professions began developing simulated patient-student menu planning encounters.(13) These simulations:

- stretch systems design capabilities by requiring free-language dialogue

- require cooperative effort between the academic division of dietetics and the hospital dietetics division
- utilize a variety of education techniques within the same course such as entry testing, drill and practice, simulation, self-evaluation

Maintenance, revision, and upgrading of the free-language patient simulations in the CASE system currently involves not only new programming techniques but also cooperation between faculty and support staffs at The Ohio State University and at the University of the Pacific.

Near the far end of the continuum of application is the Independent Study Program (ISP) within the College of Medicine. Formerly known as the pilot medical school, the ISP was initially a research project to investigate the effectiveness and efficiency of utilizing independent study for the medical basic sciences portion of medical student education. The charge which confronted the faculty was to design, implement and evaluate a pre-clerkship curriculum that would incorporate as its foundation certain educational principles and tenants of independent study. The ISP was formed as a result of a grant from the United States Public Health Service, Division of Physician Manpower.⁽¹¹⁾ The grant provided for one year of program development and two years of operation and evaluation. Several entering classes were as follows:

- 1970, 32 students
- 1971, 59 students
- 1972, 64 students
- 1973, 64 students
- 1974, 64 students

Since 1972, the ISP has been financially supported by the College of Medicine as an alternative to the lecture discussion curriculum.

A recent publication by J. V. Griesen (3) offers a good overview of the independent study program and reports some of the initial research findings. An additional publication (14) offers a review of the philosophy and history of the curriculum, an outline of the curriculum (including objectives) and a discussion of the research findings. Basically, the student moves at his or her own rate studying modules and submodules (logical units of information organized by body systems with given objectives) and taking CAI self-evaluation exercises to help assess knowledge acquired before moving on to the next submodule. It is important to note that Computer Assisted Instruction is not used as a tool for initial presentation of materials. The student studies independently the resources outlined by the faculty and goes to the CAI terminal for tutorial self-evaluation (TES) exercises which are designed to provide one with an individual gauge of success in meeting the objectives of the modules. Figure 2 is a block diagram of the independent study curriculum and Figure 3 is a flow chart

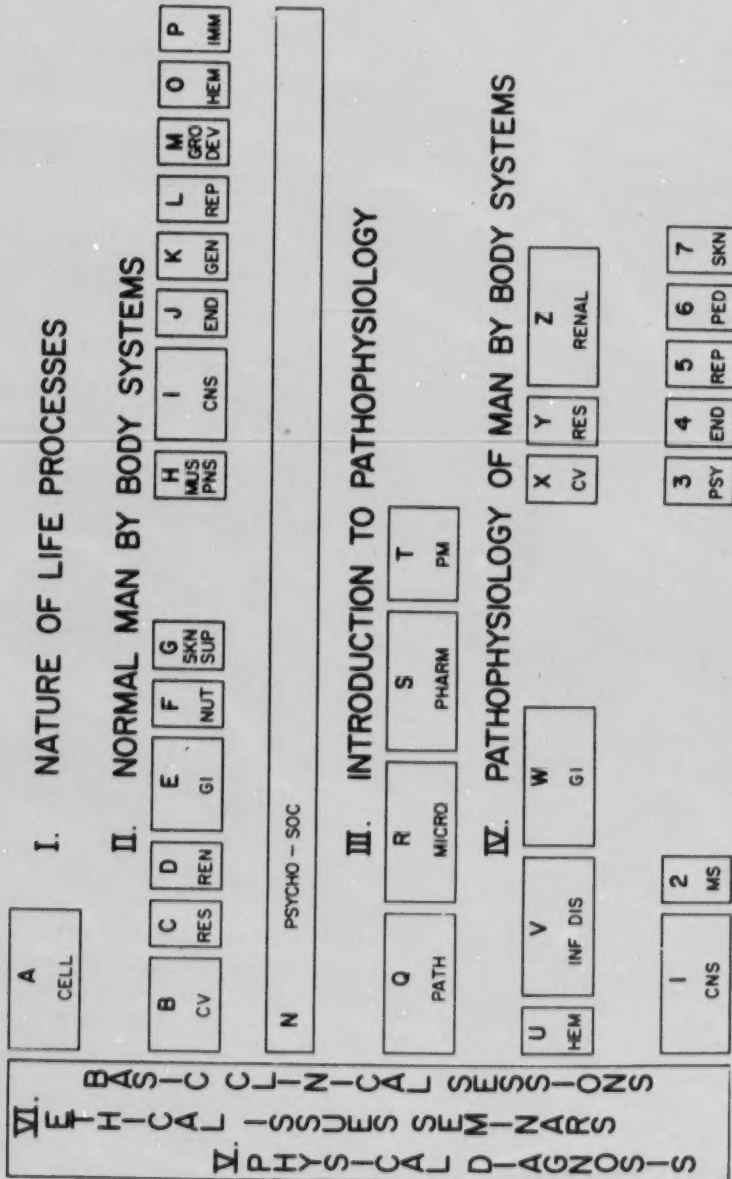


Figure 2. Independent Study Program Curriculum

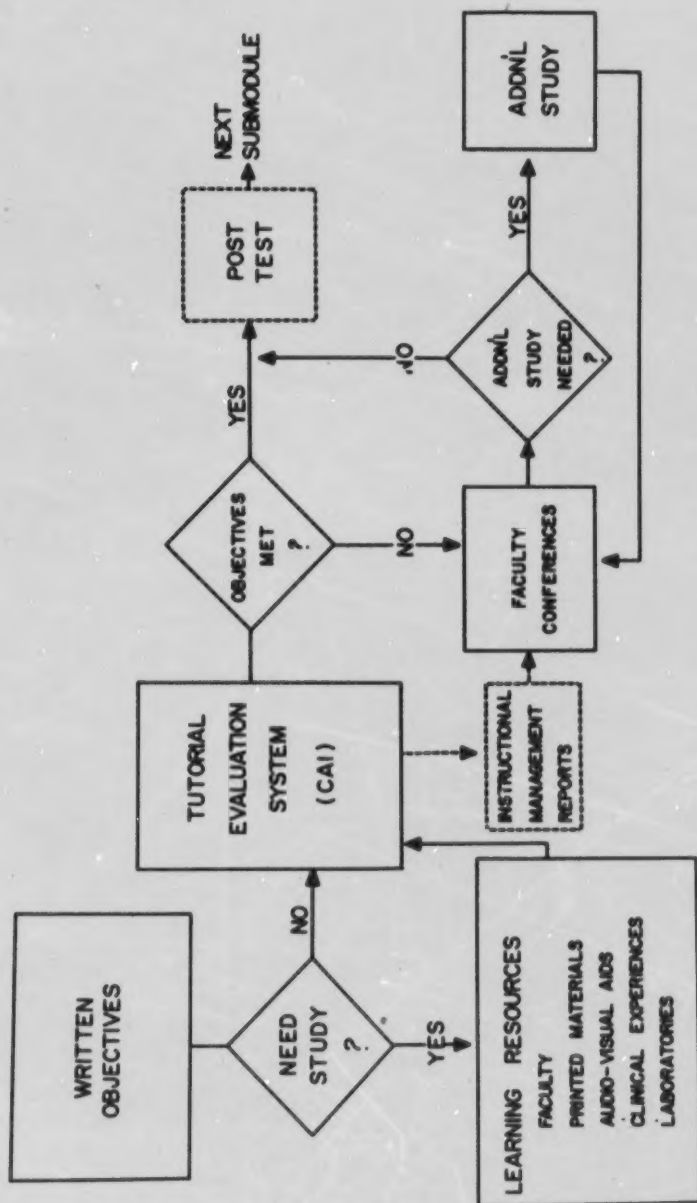


Figure 3. Student Flow through Each Submodule

depicting student flow through each submodule. Appendix D gives a sample student flow through TES item.

Reference to the continuum indicates that the definition of the independent study curriculum and the subsequent writing of tutorial self-evaluation exercises requires considerable interdisciplinary effort by the faculty representing the basic clinical sciences.

Continuing Medical Education

Given the initial success in the College's CAI applications, medical educators at the College of Medicine received funds (15) to establish a pilot network to assess the feasibility of applying computer technology to the continuing education needs of Ohio's physicians. During the initial phase in 1968, fully subsidized CAI terminals were placed in four community hospitals chosen to represent various geographical areas of the state. Success was not immediate for several reasons:

- the limited scope of the library of available CAI programs (less than twelve interactive sessions)
- the absence of maintaining stable on-line terminal connections to remote areas of Ohio
- the limitation of the audience to only physicians

By 1969, project goals were expanded to include other health profession audiences and the network was expanded to ten hospitals within the state. From 1969 onward, subsidy to the hospitals declined until each was paying fully for terminal linkage to The Ohio State University. In 1974, over twenty institutions pay for CAI services through a Computer Assisted Instruction Regional Education Network (CAIREN) which provides continuing education to all types of health personnel. A field coordinator meets regularly with hospital continuing education committees, administrators and staff to assist in planning the usage and development of CAI courses for each institution.

Throughout its history, the continuing education effort has maintained the premise that "the quality of patient care and health care services is contingent on the knowledge and skills of the health professions; therefore, the maintenance of the current knowledge and skills is of vital importance to the health practitioner." (7) CAIREN offers the availability of CAI to hospital personnel on all shifts, every day of the week for both inservice training and orientation programs. CAI continuing education courses are accredited for usage in Ohio by six professional societies:

- The American Medical Association
- The American Osteopathic Association
- The Ohio Osteopathic Association
- The State of Ohio Board of Pharmacy
- The Ohio Council for Medical Technology
- The American Dietetics Association

Many courses developed for the continuing education environment have proven quite useful for undergraduate training in nursing and allied health professions; the reverse has also been true.

Patient Education

As a direct result of the continuing education efforts, courses were developed in specific areas of patient education. Courses in patient care of diabetes, instruction to mothers regarding care and feeding of newborns and information for the parents of the juvenile with diabetes are examples of CAI applications available in the patient education arena.

Non-Medical Support Staff Education

Also as a result of interface with the continuing education hospitals, courses were developed for non-medical support staff, like secretaries. A new course on the medical record was developed for one hospital and a course in medical terminology developed for OSU College of Medicine students has also been used by secretaries and medical typists in the hospitals.

AUDIENCES

To summarize from a different perspective, College of Medicine CAI applications can be useful to many audiences. Table 1 lists the number of CAI courses relevant to specified audiences.

A detailed indexing of all College of Medicine CAI materials along with course descriptions is available in the *User's Guide to Computer Assisted Instruction at The Ohio State University College of Medicine*. (10)

CONFIGURATIONS FOR USAGE

Looking at The Ohio State University College of Medicine CAI System from another perspective, one can view the configurations for user access to the materials described above. Basically two configurations for access are used:

- *an on-line configuration* in which the user links directly to the CAI data base at The Ohio State University College of Medicine
- *an off-line configuration* in which the user installs a portion or portions of The Ohio State University College of Medicine CAI System on his own computer

In efforts to facilitate sharing, the college has released materials in both configurations.

Table 1
CAI Courses Indexed by Audience

<i>Audience</i>	<i>Number of Courses</i>
Clinical Laboratory	12
Dietitians	16
Dental Personnel	5
Emergency Medical Technicians	10
Environmental Services	8
Management	6
Medical Records	8
Medical Students	52
Nursing	46
Occupational Therapy	15
Optometry	5
Patients and Families	8
Pharmacy	6
Physical Therapy	15
Respiratory	13
Radiology	14
Secretarial	10

On-Line Configuration

The on-line configuration has three subsystems: a local network (within the city of Columbus); a state-wide Ohio network; and a national network.

In the local configuration, 20 terminal sites exist within the city of Columbus for accessing CAI courses. The largest number of these are in the Health Sciences Library on The Ohio State University campus. To use a CAI course, the student comes to the monitor's room, checks out a key and associated visuals (if needed for use in the CAI session), and proceeds to the terminal room where a high speed printer terminal and slide projector are available. Other CAI terminals are located in support staff offices and at local continuing education institutions.

The State of Ohio configuration consists of some 20 institutions throughout Ohio linked directly via telephone to Columbus and The Ohio State University College of Medicine site.

In 1972, under a grant from the Lister Hill National Center for Biomedical Communications of the National Library of Medicine, (12) the College linked its data base to a network for CAI access in the United States. The purpose of the experimental network is to test the inter-institutional sharing of CAI materials housed at The Ohio State University College of Medicine and at Massachusetts General Hospital in

Boston.(5) The hardware network is maintained by the TYMSHARE Corporation of Cupertino, California, and is a combination of minicomputers with high speed lines linking cities in the United States and Europe.(1)

Users on the national network vary from small hospitals to major medical centers, and the type and extent of usage varies as much as does the type and size of institution. By far, the largest number of users are presently reviewing available materials with no commitment of long-range usage. Several institutions, however, have made long-range commitments for utilization. The University of Washington in Seattle has accessed The Ohio State University Independent Study Program and altered it to meet local specifications. This institution is currently operating its own ISP, and, by network connection, is using CAI at The Ohio State University. The University of Pittsburgh in association with Pittsburgh Eye and Ear Hospital is using ophthalmology materials and has recently begun to develop its own CAI materials using the CAI support staff at The Ohio State University College of Medicine. The University of the Pacific in cooperation with the American Board of Internal Medicine is refining, revising, and generating CASES in The Ohio State University data base. Fort Worth Osteopathic Hospital utilizes continuing education materials.

As of September, 1974, the average percentage of total CAI system utilization by access group is:

- Local Network 50%
- State Network 30%
- National Network 20%

Off-Line Sharing

Under the auspices of the College's policy for CAI materials release, all CAI materials (except those restricted by the author or by copyright concerns) are available for release on a cost recovery basis to other non-profit institutions. The policy facilitates sharing while protecting the author and the college. Through October 1974 over 350 course and program units have been distributed via this policy to 70 institutions in the United States, Europe and South America.

SUPPORT CONFIGURATION FOR CAI

At The Ohio State University College of Medicine there are two major sets of actors in CAI development and usage, the authors and the support staff. The authors of CAI materials (10) are most often college faculty, although students have authored several allied medical and basic anatomy programs. Student authors may receive graduate credit for developing a viable program. Three primary support units house the second set of actors, the support staff (see Figure 4).

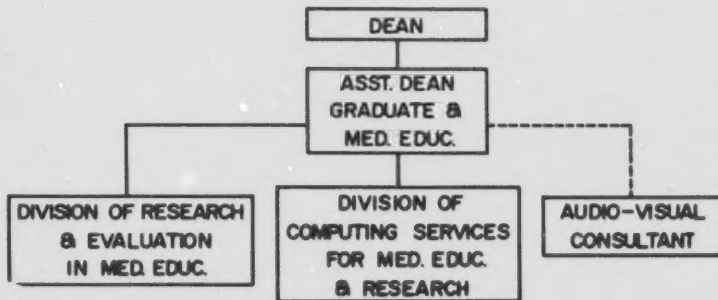


Figure 4. CAI Support Units

The audio-visual coordinator links audio-visual production with the educational application of the audio-visuals. He or she maintains a catalog of all visuals used with CAI courses, and controls master sets of each visual unit. When any CAI course is requested, and audio-visual coordinator insures that appropriate visuals are duplicated, labeled and quality checked for distribution to the user (either local or remote). The coordinator also upgrades visual sets as CAI courses are continually reviewed and revised and works as a free lance consultant to other support units, to curriculum and project areas, and to individual faculty members.

The Division of Research and Evaluation in Medical Education assists in research and evaluation design studies involving CAI. This Division also interfaces with all college curriculum committees and helps set priorities for new CAI development.

The Division of Computing Services for Medical Education and Research:

- Maintains all hardware including computer, terminal, telephone, etc. Maintenance responsibilities include installation and trouble shooting for all equipment.
- Maintains, develops and upgrades existing CAI course. An example of the effort expended in this area was the recent conversion of all Medicine courseware from 100 character line length to 70 character line length.
- Maintains, develops, and upgrades software for the COURSEWRITER III language and CAI System. An example of this support was the addition to COURSEWRITER of numerical and algebraic manipulation capabilities. (9)
- Maintains, develops and upgrades software for the Computer Assisted Instruction Reporting System (CAIRS). This includes student and system usage reports. (6, 16)
- Develops new CAI courses (see paragraph below)
- Performs all user interface functions including maintenance of an on-

line *User's Guide to Computer Assisted Instruction*, distribution of sign-on procedures, CAIREN field coordination, and so on.

The support team for development of new CAI courses is one of the strong points of the CAI environment at the OSU College of Medicine. The chart shown in Figure 5 schematically depicts the CAI development team. The major actors are the author and the instructional programmer (IP). The instructional programmer serves as the primary interface between the author and CAI hardware and software. The author remains the content specialist, while the instructional programmer: a) consults with the author regarding objectives, strategy, and design of the material; b) codes and inputs the material in the COURSEWRITER language; c) works with the system programmer in design of new course facilities or systems functions to effect the course strategy; d) works with the systems analyst to design student reports and/or course analyses as required by the author; e) arranges for review students to test new CAI courses; f) arranges for additional content reviewers as required; g) consults with the author and the audio-visual consultant on the use of audio-visuials in conjunction with the CAI courses; h) serves as the ongoing caretaker and trouble shooter for the course once it is made available for student usage which includes continual monitoring of student comments; and i) monitors and helps interpret item statistics and student usage reports for evaluation and revision of materials.



Figure 5. CAI Course Development Team

Since the IP is expected to be a "Jack of all Trades," he or she must have available back-up resources in most areas. An audio-visual consultant, education strategy consultant, course management supervisor, systems programmer and report analyst are all available as needed to assist the instructional programmer. The IP's for the most part have backgrounds in education rather than in computers or health; they are trained in computing techniques on the job.

The structure of the course development team and the professionalism of the newly defined instructional programmer are key elements in the current success and continuing involvement of CAI at The Ohio State University College of Medicine. On the average two to four hours of new interactive materials are produced each month.

CONCLUSION

Several factors have been significant in the history of CAI growth at The Ohio State University College of Medicine. They are still significant in 1974.

- *Educational strategy and in content application of the CAI materials always holds priority over fancy hardware and/or computer systems.* The current strength of the College of Medicine CAI System is the breadth and depth of its courseware, not the elegance of its hardware.
- *Each CAI project, curricular effort, or course utilizes staff and expertise in existing College support units.* Small support fiefdoms, each recreating the wheel of CAI, are not allowed to form. Each effort builds upon the knowledge and expertise of past efforts. Lessons learned by support staff or authors on one project are applied immediately to other projects. Personnel and system resources are shared by all efforts in a cost-effective and coordinated fashion.
- *Definition of what is to be developed comes from outside the CAI support unit:* thus alleviating any tendency for support unit to breed a life of its own. Decisions on the priorities for new CAI development come from directors of the curricular areas, from the field coordinator for the CAIREN network, and from content specialists. The support unit functions according to the needs and priorities given.
- *The structure of the CAI course development team is crucial in assuring continuing development and revision of CAI courseware.*
- *The College has maintained a commitment to an operational system with continuous uptime and usage.* This environment facilitates growth and integration of CAI into the College curriculum without prohibiting research and development. It also paved the way for transition of CAI support from soft to hard dollars.
- *Introduction and gradual incorporation of CAI materials into existing college curriculums is effected by creditable faculty in each area.* Although the integration often moves slowly, it will not move at all without support from faculty in the content area.
- *Administrative support for the CAI effort has been present particularly in the early developmental stages.* Such support is crucial if problems such as faculty recognition for CAI development are to be addressed.

In closing, this essay would be remiss if it did not stress the importance of outside funding for large scale CAI development. The costs in staff time alone for efforts such as development of the ISP are so high that few institutions could afford the investment.

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Part IV

Networking

for

Instruction

Chapter 15

HIERARCHICAL NETWORKING IN HIGHER EDUCATION

by Laurence H. Baker

Alternative ways of delivering computing in academic institutions have been described in depth in Greenberger, et al. (1974), Mosman (1974), Spriestersbach (1973) and Williams (1974). These references have described campus computing requirements as well as resource sharing among universities. This discussion will focus upon the delivery of computing in the California State University multi-campus system of higher education often referred to as the One-Thousand Mile Campus.

A hierarchical network for computing has developed logically from the structure and needs of The California State University and Colleges (CSUC). Following a brief description of CSUC, this chapter reviews steps taken in planning computing activities and in determining CSUC computing requirements. Closing sections outline present computing resources and their limitations and describe the CSUS hierarchical network.

THE CALIFORNIA STATE UNIVERSITY AND COLLEGES

The California State University and Colleges provides undergraduate and graduate instruction in the liberal arts and sciences, in applied fields and in the professions. On nineteen campuses located throughout the State of California, approximately sixteen thousand faculty serve a regular student enrollment in excess of 285,000 students.

PLANNING COMPUTING ACTIVITIES

In the CSUC system planning for computing activities is a continuing process. Responsibility for the planning, coordination, and administration of data processing activities, including all data processing equipment acquisition, has been assigned to the Division of Information Systems within the Office of the Chancellor. Campus level operational responsibility is delegated to a campus manager or director of automatic data processing services, although concern and ultimate responsibility for campus success resides in the president of the local campus and his or her administrative and/or academic support staff.

The Division of Information Systems is headed by a director who assumes overall responsibility for the planning, budgeting and administrative support activities. Reporting to the director are associate directors for operation, administrative applications and instructional support who collectively interface with their respective counterparts on the various campuses. The director is advised by a representative committee comprised of three faculty members, three data processing managers or directors and other representatives of campus administrative activities. The management advisory committee is chaired by a president of one of the larger campuses. Ultimate responsibility for the formation of policy under the state law resides in the Office of the Chancellor and in the Board of Trustees. However, in the budgetary and procurement process, the activities of the division are monitored by the State's Department of Finance in order to insure compliance with legislative and legal intent as defined in the law and annual budgetary allocations.

While consolidation of computing centers for all state agencies has been prescribed as legislative intent, all plans for procurements presented by The California State University and Colleges have been supported by the State Department of Finance.

CSUC COMPUTING REQUIREMENTS

In addition to planning, the Division of Information Systems of CSUC also has responsibility for satisfying the administrative and academic computing requirements of the entire system. Computer-supported administrative systems used within the system office to guide the instructional process include applications designed to support admissions, budgeting, accounting, analyses of faculty workload, space utilization and the development of enrollment statistics. Administrative systems used on each campus include those designed to maintain student records, assist with registration and support the administration of student financial and programs.

Academic computing support requirements are primarily instructional and can be classified as follows: use of the computer as a tool for system

design and programming; data base manipulation; instructional games; packages and planning languages; computer assisted instruction and computer managed instruction. These categories are designed to support undergraduate education. Some research capabilities are required, however, they are more limited than those listed as instructional.

The Division of Information Systems has developed an instructional workload model to establish objectives concerning the computing resources required to satisfy the educational program of The California State University and Colleges. In one planning study it was used to determine the proportion of faculty and student problems which should be directed to batch processing compared to interactive timesharing. A major result of that study was the conclusion that the majority of instructional requirements can be satisfied using minicomputers which are now available. Based on these results CSUC system office personnell are no longer convinced that Groseh's Law continues to hold for undergraduate education where a large general purpose system can be shared by multiple campuses.

With the availability of minicomputer technology a combination of interactive computing and batch processing is a superior basis for supporting undergraduate education than is one alternative alone. This is true in terms of cost effectiveness (CSUC Feasibility Study) as well as in terms of the instructional environment provided (Spriestersbach, 1973).

PRESENT COMPUTING RESOURCES

Computing hardware available throughout the CSUC system in 1974 is listed in Table 1.

The nineteen campus computers are linked via communications facilities with the systemwide batch and timesharing computers to form a star network. This network, which has existed since 1968, enables the medium-sized computers on each campus to communicate with the more powerful batch configuration located in the State University Data Center. Timesharing data communications requirements are satisfied by the same network using multiplexors capable of multiplexing up to 130/110 bps timesharing terminals to the State University Timesharing Center located on the Northridge Campus.

Three major limitations exist with the present system which result in less than adequate computing support to satisfy academic requirements.

- The systemwide timesharing computers are saturated with processing requirements.
- The present data communications system is based upon outdated technology and is not flexible enough to support the increasing load which varies from campus to campus.
- Bottlenecks exist in satisfying all instructional support requirements with present batch computing hardware.

Table 1
Computing Hardware

<i>Location</i>	<i>CPU</i>	<i>Number</i>
Campus	CDC 3150	11
	IBM 360/50	1
	IBM 360/40	1
	IBM 360/20	1
	NCR 200	1
	HIS 2020	4
Systemwide Batch	CDC 3300	Dual
	CDC 3170	Front-End
Systemwide Timesharing	CDC 3170	2
Campus Minicomputers	DEC	8
	Hewlett Packard	4
	Microdata	1
	Data General	2
	Vaniau	1
	Texas Instruments	1

A HIERARCHICAL NETWORK

Eight alternative ways of upgrading the present computing facilities to eliminate the limitations of the present system were considered by the Division of Information Systems. Each alternative was designed to satisfy timesharing instructional requirements outlined in Table 2.

Table 2
Recommended Timesharing System Attributes

- *Capacity to 512 simultaneous users
- *Capacity for 36,000 user accounts
- *5 million characters of user accessible memory
- *500 million characters of user accessible mass storage
- *Worst case response time of 3 seconds plus no more than double apparent execution time under light loading
- *Flexible port levels
- *CPU upgradable via parallel or compatible processors
- *Autobaud detect with popular terminal speeds of 110 to 2400 BAUD
- *95% hardware reliability, with graceful degradation
- *Hierarchical system usage: beginning level usage in minutes, progressing to advanced usage in three months

Table 2 cont'd

- *Intelligible and meaningful diagnostic messages oriented toward beginning users, with source level indication, single and multiple error detection on one line
- *Logic debugging capabilities, including traces, traps, maps
- *Industry and National Standard BASIC, FORTRAN, and other language capability
- *Advanced user utilities, such as text editors, object load/run system, statistics packages, mathematical subroutines, assembler, peripheral utilities, etc.
- *System software reliability and security
- *High speed or individual port input
- *Common operating systems if multiple machines
- *Common hardware and software to provide an interchange of curricular materials

Site communications personnel support, hardware and maintenance costs were all considered for each alternative. System reliability, backup power requirements and the effect of power brownouts were also considered. The most cost-effective solution satisfying all stated requirements was a hierarchy of computing resources consisting of minicomputers on each campus linked to a large central timesharing system via an enhanced communications network.

To develop this hierarchy of computing the Division of Information System will first procure nineteen minicomputers to provide a basic local timesharing capability on each campus. The size of the systems which will be obtained initially is described in Table 3.

Characteristics of typical large and small campus systems are quite different from one another. On a typical large campus the computing system will consist of a single batch processor with related equipment:

- 128 K bytes core
- 4 tape drives, 30 KC
- 4 disk drives, 32 million bytes total
- 1 Printer, 600 lines per minute
- 1 Card Reader, 1200 cards per minute
- 1 Card Punch, 250 250 cards per minute

The communications line will be 4800 Baud.

The typical small campus system will include a campus timesharing single processor with:

- 32 K bytes core
- 1 tape drive, 30 KC
- 1 disk drive, 20 million bytes
- 1 Printer, 300 lines per minute
- 32 Ports

Table 3
Local Timesharing Systems

<i>Campus</i>	<i>ports</i>	<i>capacity</i>
San Jose	32	
San Diego	32	
Long Beach	32	7 systems of
Northridge	32	32 port capacity
San Luis Obispo	32	
Los Angeles	32	
Sacramento	32	
Fullerton	24	
San Francisco	24	5 systems of
Fresno	24	24 port capacity
Pomona	24	
Chico	24	
Hayward	16	2 systems of
Humboldt	16	16 port capacity
Sonoma	8	
Dominquez Hills	8	5 systems of
Bakersfield	8	8 port capacity
San Bernardino	8	
Stanislaus	8	
TOTAL	416 ports	

For the small campus the communications line will also be 4800 Baud.

The second step in development of a systemwide herarchical network is growth of a new data communications network. The new network was designed by faculty drawn from the State University and Colleges and from the communications group within the Division of Information Systems. The network will consist of communications handlers in each region of the state capable of concentrating data for transmission over C-2 voice grade lines and switching messages within the network to the appropriate machine. This system is designed to optimize line utilization as well as resource sharing. In addition to the message concentration and switching capability, the communications handlers will transmit error detection and correction messages in order to bring communications

reliability close to the 100% level. The development of the software required to support a complex switching mechanism within the network will enable the State University and Colleges to implement a genuine hierarchy of computing resources which will be totally transparent to the computer's link to the network and nearly transparent to the individual user.

The third step in growth of the hierarchical network is the replacement of the existing timesharing system with a substantially larger, more powerful and more versatile machine capable of supporting twice the existing number of central timesharing ports and with the capability of growing to the support level required in the future. In 1974 the CSUC system has completed all planning and begun step one. With the cooperation of already involved faculty and administrators from each campus, 1975 will bring substantial progress on step two and three.

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Chapter 16

SOCRATES[©] : An Innovative Student Oriented Computer Aided Test Generator

by R. Gene Geisler

INTRODUCTION

A wide variety of factors enter the learning equation: books, syllabi, teachers, student preparation and motivation. In addition, learning resources such as audio visual materials are increasingly employed to assist the overburdened instructor. These factors are dynamic variables changing from student to student, year to year and teacher to teacher. There is however one constant, the broad outline of the learning process itself.

In the learning process as generally experienced in a university environment, faculty prepare outlines of material students are expected to master which is accompanied by a reading list and supplemented by lectures. Lectures, as a rule, amplify the subject matter and offer students the opportunity to question any aspect of the course including its content or the process. However, if the class is large as many are, feedback is usually brief and unsatisfactory. There simply isn't enough time in the day, week or month to give each student the feedback essential to a successful learning process. Without such feedback, students tend to enter

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the periodic examination situation with trepidation, a condition rarely conclusive to the attitudes necessary for optimum learning performance.

Without belaboring the point it could also be noted that in the average large classroom situation there is a wide range of student expectations, preparation, and motivation. It is nearly impossible to prepare a course which meets the need of all the students. Courses directed at the upper third overshoot the middle and lose the lower third entirely. Similar results occur when courses are directed at any other level.

WHAT IS SOCRATES?

To remedy these two situations The California State University and Colleges has prepared the computer program SOCRATES which is an easily available feedback vehicle. SOCRATES is designed to provide the faculty with class diagnostics before the course begins, and to promote student evaluative feedback at frequent intervals. Students may access the system for self evaluation and optional challenge examinations. It frees them from the tedium normally associated with the construction and scoring of student examinations. Faculty control the system. The scoring output may be ordered in such a way that a class may be evaluated in the traditional multiple choice mode or employed as a class diagnostic enabling instructors to direct course content to specific groups with clearly identifiable needs.

In the long run SOCRATES will be interfaced with audio visual as well as traditional textual material to supplement and personalize an individual's education. Individualization and personalization have long been "buzz words" with administrators and reform-minded foundations. However, because these methods require increased faculty workload such goals have remained, for the most part, idle dreams. SOCRATES is designed to help the instructor achieve this dream.

The program is currently being implemented on a pilot basis within the California State University and is operational. As soon as it meets the technical and documentation standards of the California State University Division of Information Systems the program will be available to other users on a cost recovery basis. The data bases or test item banks are in the public domain although the program is the property of the California State University. Inquiries concerning the availability of the program and the test item banks should be addressed to the author of this article.

SOCRATES is a comprehensive computerized testing system which makes possible the establishment and maintenance of machine-readable banks of test items. From these banks the computer can construct tests and exercises according to specifications supplied by faculty and/or students. SOCRATES will:

- produce printed tests on a computer line printer
- display test items on interactive computer timeshare terminals

- score exercises and produce analytical scoring reports
- maintain item-by-item records on usage and on student response patterns
- accommodate a variety of educational strategies, and learning objectives

Because SOCRATES has been programmed in standard ANSI COBOL, it is machine-independent. It will operate on the computers which The California State University and Colleges now has and on any it will have in the foreseeable future. Because of its modular design the SOCRATES system can be modified to take advantage of improved computer facilities and to meet changing educational needs. It will also be available to other universities with almost any computing configuration.

The computer programs necessary to support SOCRATES were developed jointly by the CSUC Office of New Program Development and Evaluation and the Division of Information Systems in concert with a system-wide faculty steering committee. System design specifications were determined by an advisory committee of CSUC faculty based on perceived needs. Programming was entrusted to a team of graduate students in computer science at California State University, Chico. The project involves five programming modules.

- *Module A* encompasses the establishment of machine-readable files of test items, the modification of those files, and program maintenance.
- *Module B* makes it possible to generate tests from the files according to specifications supplied by the user. It also provides for computerized test scoring and the maintenance of item statistics.
- *Module C* involves test generation by interactive terminal. It eliminates the need for keypunching and allows immediate faculty review of test items, as well as student self evaluation and challenge examinations.
- *Module D* permits students to access the banks by interactive terminal for self-paced instruction.
- *Module E* is still under development and includes a variety of applications that are considered unusual or especially innovative. It will make possible the coordinated use of interactive terminals and audio visual materials in a multi-media learning center environment. It will accommodate different kinds of answers than those usually associated with objective test items (textual answers; graphically located answers; sequential answers; matching answers). It also includes special statistical and record-keeping applications that will encourage faculty to diagnose individual student problems and provide individualized assistance.

EASE OF UTILIZATION

The system is supported by a group of forms which are virtually

self-explanatory. A complete set of these forms which include test item requests, addition or deletion, request and a scoring mode request, are reproduced in Appendix E. These forms can be submitted by faculty to a local data center for punching or can be entered in timesharing mode where a faculty member is prompted to supply the information required by the program to provide the service desired. SOCRATES edits the request to insure adequacy of information and formats it for processing. Faculty and student users need know little more than the English language in its written form. They are specifically freed from considerations of format, job control card sequence, file structure, etc. in both the timesharing and batch modes.

SOCRATES is thus available to the least technical member of the faculty as well as the traditional computer buff.

TEST ITEM COLLECTIONS

Test item collections have been established by many others in addition to the CSUC faculty. In addition to a large bank in United States history (approximately 15,000 items) test item banks currently supported by SOCRATES include: mathematics; chemistry; physics; biology; psychology; accounting; astronomy; economics; sociology; tests and measurements; and counseling and guidance. In several fields where formal comprehensive examinations are being developed by CSUC faculty SOCRATES will probably serve as the delivery system. The System is currently developing comprehensive examination methods and bases in chemistry, accounting, economics, political science, and recreation.

Established test item collections must be continually evaluated, revised, updated, and expanded. For each collection, a single coordinator or a coordinating committee is designated. In addition to answering user questions the coordinator approves additions, deletions, and editorial changes.

SOCRATES' record-keeping capabilities facilitate item validation. The system maintains permanent records on the number of times an item was selected for an exercise and the number of times it was deleted by faculty request. It also maintains an item-by-item count of student responses. The coordinator can receive an automatic print-out of all items rejected or answered incorrectly more than a certain proportion of the time on an exception report basis. He or she can also request similar reports on items with distractors (incorrect responses) that are too strong or too weak.

Because the test items are being used on a system-wide basis, statistics accumulate rapidly. This built-in mechanism for quality control and item bank improvement is potentially one of SOCRATES' most important features.

HOW DOES ONE USE SOCRATES?

For each item collection there is a numerically coded category index from which a faculty member selects categories that describe the areas to be covered. Keywords, coded cross-references, permit the specification of content within categories. The faculty user may designate a difficulty level for each category block (easy, average, or difficult). He or she can also select or exclude certain types of questions: items that call for factual recall; items that test skills and attitudes; items that are associated with charts, maps, pictures, or diagrams; and clusters of items relating to a table or printed text. Finally, since each item is associated with a unique identification number, faculty users can request specific items.

After SOCRATES has constructed the exercise and listed it, the instructor may reject items. SOCRATES will, on request, replace the deleted items with other items which have the same characteristics or different characteristics. The cycle of listing, review, deletion, and replacement can be repeated as many times as necessary. If the faculty member places his or her order via interactive terminal, the process may be speeded up. As each item is listed, the user is asked to accept or reject it. If he or she rejects, an alternative item with the same characteristics is chosen. When the entire exercise has been constructed and approved, the user may receive an immediate listing on the terminal. Alternately he or she can have the exercise listed on the computer line printer. In either case, the faculty member is in complete control of the process.

There is no restriction on the ways in which an exercise may be used. It could be an ungraded diagnostic exercise, a take-home test, or an open-book examination. It could be used for 100 students in a traditional survey or for a single student in a personalized environment. It could be used in conjunction with other questions supplied by the faculty member. Instead of homogenizing education SOCRATES encourages and increases faculty teaching options.

Scoring is also under faculty control. A faculty member can score examinations by hand or through a scoring package available on each campus. If he or she scores through SOCRATES, a wide range of statistical options are available.

Students will use SOCRATES via interactive timesharing terminals. In some cases the student will access an instructor-created exercise and records will be kept by SOCRATES. Alternatively students will use the test item banks directly for self-paced drill and instruction in which case no record will be maintained. SOCRATES will also serve as a vehicle for delivery of challenge examinations in which student use will be supervised, and the test result will be recorded for use by faculty and the registrar.

IMPLICATIONS FOR THE INSTRUCTIONAL PROCESS

SOCRATES suggests a change in the way faculty time is used. Current job definitions stress hours per week of classroom contact. Item bank maintenance will require assigned time for the continuing identification of instructional objectives and the development of instruments to measure achievement. It will be to the benefit of the university to involve as many teaching faculty as possible. SOCRATES will also free faculty from much menial chore work and provide them with sophisticated analysis of student performance.

Within the classroom, teaching and diagnostic examinations will become more numerous and the rapid production of individualized exercises will facilitate a number of teaching strategies:

- more frequent testing
- diagnostic testing (Module B anticipates a Guttman scaling program that will group students according to the kinds of competencies they possess.)
- credit-by-examination (Module D includes a delivery system for challenge examinations.)
- comprehensive examinations (Security requires that many equivalent versions can be generated on a random basis. SOCRATES provides an ideal vehicle for test construction and delivery.)
- modularized instruction (giving the student multiple chances to demonstrate competency in a defined area)
- personalized systems of instruction
- self-paced instruction

Part V

**Management
of Institutions
and Systems**

Chapter 17

COMPUTER INFORMATION SYSTEMS FOR UNIVERSITY MANAGEMENT

by Richard L. Van Horn

With many universities in trouble, computer-based information systems to enhance or enable effective management occupy a position of great interest and visibility. In turn, the manager-systems designer conflict remains an often discussed issue related to the usefulness of management information systems. The arguments are well known by both sides. Managers are: captives of past practice; consider few alternatives; do not understand the limits and capabilities of technology; and have no realistic view of schedules, risks, and costs of systems work. Systems designers: are fascinated and pre-occupied by technology; are eternally optimistic about the abilities of themselves and their systems; have only the vaguest notion of management problems; and make most design decisions on the basis of their own and the computer's convenience. This conflict, so the argument continues, inevitably must lead to less satisfactory information systems.

After 20 years as a researcher, designer, and teacher of management information systems, the author as a major user of the Carnegie-Mellon University system in addition to being responsible for its development and operation, offers in this paper some comments on university information systems from a dual user-designer viewpoint.

The user-designer conflict is real and the above descriptions of managers and designers are reasonable stereotypes. However, the conflict as stated is largely irrelevant or at least not limiting. Both sides recognize biases, at least in part, and compensate for them. Computerniks and

managers understand each other far better in 1974 than in 1954. The remaining conflict may raise cost and tempers, and certainly it deserves continuing attention and effort, but the real impact of this conflict on the usefulness of the end systems in a university is small. On the other hand, computer information systems do not appear to be central to most planning and control decisions in universities today. The problem is more closely related to Frederick Taylor than to John Diebold.

CMU INFORMATION SYSTEMS

Carnegie-Mellon University is a medium-sized, private, research-oriented university. The school has approximately 3,100 undergraduates, 1,200 graduate students, 480 faculty members, 1,200 staff employees, an education and general operating budget for \$20 million, and a total budget including research and auxiliaries of \$40 million. Administrative information systems use part of an IBM 360/67 with extensive disk storage located in a combined University Computation Center. The 360/67 operates under TSS, a now somewhat rare and exotic time-sharing monitor; but information systems programs are written in a standard COBOL. Most administrative centers on campus have teletypes for data entry and run control, and most programs are executed at night in batch mode. The information systems staff of 10 programmer-analysts form a separate department outside of the Computation Center.

In rough order of operational priorities, application areas include: payroll; admissions including status and communications management for all applicants and inquiries; accounting and budgeting; development including alumni records, gift record, and so on; and registrar including student records, personnel, inventories, and special studies. In summary, CMU has extensive data processing equipment, working programs for all typical application areas, and a competent staff. The system represents a balance between cost and service that appears appropriate for the size and functions of CMU.

MANAGEMENT IMPACT

Information systems are used for a variety of management tasks. One standard characterization of tasks is operation, control, and planning. CMU operations clearly depend heavily on computer support. Without computer support, the university could not for long pay employees, keep financial records, respond to applicants, communicate with alumni, provide transcripts to students, or, in short, remain in business. Problems in this area are largely due to limited resources. While CMU administrators recognize the possibilities and need for many improvements, they also know in broad outline what to do and how to do it. CMU certainly plans to continue building systems in this area, but appears to have achieved at least a satisfactory minimum level.

Whether or not a university thrives, or survives, may relate more closely to management planning and control. The impact of computers on these areas is less clear. For control, CMU administrators depend on computer systems largely for a comparison of budgeted versus actual expenses and income. For planning, the major computer system base is a listing of expenses and income over the years. CMU administrators also recognize and indeed make decisions on a large number of other factors, but the values for those factors come from estimates, feelings, hunches, and biases of deans and other administrators. In short, standard financial data are the only major product of our computerized information system relevant to planning and control.

Business firms have encountered this same problem a number of times and by now have made substantial progress. Many firms have large data-bases containing extensive data in addition to standard financial statistics to support a variety of planning and control models and activities.

Planning and Control Problems

With respect to planning and control, university managements in many instances appear to lag behind the more innovative business firms. However, universities do face a number of special complexities. In both cases, the difficulties are due more to inadequate development of basic management structures than to a failure to understand and utilize information systems technology.

OBJECTIVES

Business firms do tend to have one clear objective to maximize profits. In the short run, they may observe other sub-objectives such as public image, market share, or survival, but, in the long run, all of these objectives fit within an overall profit goal. In a business firm, planning and control obtain shape and direction from that simple, single, goal. The market system provides a great deal of information to evaluate the validity of various planning and control efforts.

Objectives for universities are less clear. The market is distorted by the fact that private and public schools sell similar products at greatly different prices. Thus private schools must claim to sell some special product like excellence or an ambience of privacy, pleasantness, or exclusivity. Students may pursue private education for consumption or as an investment related to future income.

Objectives for a private university in this environment might include: survival; offering a product superior to public schools; or contributing to public welfare. In practice, the goal becomes to provide a specified

research and educational program within the constraints of a balanced budget. Even if a university management clearly agreed on a set of objectives, the relationship of those objectives to faculty effort, teaching, counseling, course development, green grass, or clean buildings is ill-defined. Thus universities can never quite agree on the desired results of planning and controlling.

Marginal Effects

Most university data provide either average or total values. One key to survival for a private university is to look for actions with marginal benefits greater than marginal cost. Thus we need data on marginal effects. This problem is well-known in business schools, occasionally recognized in business, and largely ignored in universities.

For example, the Resource Requirement Production Model of NCHEMS is a linear, average cost model. Increase enrollment by 20% and resources and cost go up by 20%. However, the vital question to a private university is how to add students at little or no cost. Some classes may not be full, or there may be a way to increase faculty productivity. An information system that provides data on marginal effects is a prerequisite to most meaningful planning models.

Aggregation

There exists in systems design a general principle that data partitions should correspond to decision points. Generally, we think of the problem as level of detail, but it has a more subtle form. An example may illustrate this meaning. CMU has six academic colleges consisting of 33 departments in its catalog. The accounting, registrar's and systems people tend to aggregate data by the catalog structure which is a reasonable but misleading process. Administrators manage by a different structure. For example, the undergraduate Economics program is part of the College of Humanities and Social Sciences in the catalog. However, all the faculty and resources belong to the Graduate School of Industrial Administration. Since most enrollment, tuition dollar, and financial aid statistics appeared in 1974 planning information systems in catalog aggregation by college, administrators found them of little use for management. Even now that the problem is corrected, one has no easy way to revise the past data base for comparison and forecasting. The university has learned that management structures change often and systems staff are careful to keep the structures in tables and out of the code in our programs.

Definition

Administrators often ask themselves (and other schools ask them) such

simple questions as how many students, or faculty CMU has, what the budget is, etc. Often the administrator has no answer. Just as comparison across schools is difficult, CMU has many budgets arranged in different ways with the same names that mean different things. One does not know how many faculty members CMU has. Are part-time faculty members counted as faculty members? How are they counted? How does CMU count a tenured part-time faculty member, a visiting faculty member, or graduate student instructors? All this may sound trite, but it is important. In order to control or plan, one must know how many faculty a particular unit actually has at present.

Measurement

Once one leaves dollars to examine other indicators, measurement becomes critical. CMU has a common unit of teaching. Each student takes about 48 units each semester. The computer based planning system tells administrators how many units each department generates each semester. But what then? Are history and physics units equal? What about small seminars versus large lectures, versus laboratory courses? Is quality relevant? One can list endless measurement problems.

The Central System

Most CMU computer support packages are designed to serve managers in the central administration. Yet the overwhelming majority of our funds are spent and activities conducted by decentralized organizations like our colleges, divisions, and departments. For example, until 1974, CMU department heads did not know how many dollars of tuition were paid or how much financial aid was received by their students. They still are not quite clear (for good reasons) if they should care. Most businessmen might be understandably wary of an enterprise in which the retail store managers neither know nor care about the sales figures.

SUMMARY

Are computerized information systems useful to university managers? Of course. Most could not, or at least prefer not to live without them. One depends heavily upon them to operate universities. Will improved disk files of the IBM 3330 type, amazing processors of the DEC 11 breed, low-cost communication terminals with scopes, information retrieval systems such as developed at Stanford, better COBOL, and many related things improve the picture? Emphatically, yes. Should one actively pursue mathematical programming models, simulators, and opinion survey techniques? Again, yes. All of these things can lead to better university management.

However, given limited resources, do the above questions address the right problems? Probably not. The major weakness is control and planning. These two areas are in trouble as a result of the basic, well-known problems discussed earlier such as agreement on objectives, marginal effects, aggregation, definition, measurement, and over-emphasis on central systems. These problems require a great deal of painful thought by senior managers like presidents and deans who seldom have the time or inclination to deal with them. Substantial and often tedious work is also required of analysts and planners, most of whom by now are victims of budget cuts. Universities seem to be making progress, but slowly at best. If universities are to thrive, they somehow must find a better way to share this limited progress for mutual benefit.

Chapter 18

ORGANIZATION OF DATA PROCESSING WITHIN A LARGE ORGANIZATION*

by Robert Beggs

Data Processing, as a function, with any organization be it large or small, must be organized and managed in a manner which is consistent with the aims and objectives of that organization. Furthermore, that function must be an integral part of the host organization. Stated another way, the data processing function must be compatible with the other major functions in the enterprise in order to ensure that it is not looked upon as a specialized appendage to the organization.

There is no scarcity of material in the literature with respect to the technical subjects which are part and parcel of every Data Processing Manager's day-to-day responsibility. This paper speaks to the broader subject of integrating the data processing function with all of its unique methodology and jargon into the larger enterprise.

It is essential for the data processing function to have a mission. Mission is defined here as a strategic objective which has either been assigned to it by the top management of the organization or which has been developed by the data processing function and explicitly agreed to by top management. Strategic objectives or missions within this context would have a planning horizon of not less than three years and the norm would be more like five years. Once the strategic objectives have been

* This paper is a condensation of an address given to the 1974 CIPS Conference, Ottawa, Canada, June 11, 1974. It is printed in edited form with permission of IBM Canada Ltd., ©Copyright, IBM Canada Ltd. 1975.

established, it is then possible for the data processing manager to establish more specific objectives which tend to have a much shorter time horizon in the order of one to two years.

Objectives might, for example, be:

- efficient operation of existing systems to produce timely and accurate results
- reduction of administrative costs by providing more cost effective ways of dealing with volumes or handling more complex transactions.
- provision of information for management decision-making.
- The development of database systems within the framework of a long-range applications plan.

Having established the mission, it is then essential to understand or create the environment which will either provide the greatest opportunity for success in meeting the objectives or, as a minimum, will provide the fewest constraints. Such an environment has at least three distinct characteristics, the first of which is the philosophy of operation. The philosophy of operation outlines: whether or not the data processing function is to be a centralized service agency or decentralized to the major functions of the enterprise; whether or not the services rendered are to be charged to the end users; whether or not the function is to be a cost centre, profit centre or neither; whether or not the same planning and control disciplines applied elsewhere in the enterprise are applied equally in data processing.

Regardless of the decisions made in these areas, it is essential to have clear and unambiguous lines of responsibility and accountability both for the operation of existing systems and the development of new systems.

With this kind of philosophical base, it is possible to determine the level at which the data processing manager would report with the organization. In this regard the author maintains that the DP manager must, to be effective, report to the equivalent of the corporate office. If the DP function is to be decentralized across the enterprise, the DP manager should report to the chief operating officer of the division of which he or she is a part. If the function is to be centralized, the DP manager should report to the institution officer to which all other service functions report.

Finally, the data processing organization must have a clear and enlightened understanding of the make-up of its user community. If user satisfaction and user perspective are key elements in being able to meet objectives, it is essential that the data processing manager understand the aspirations, pressures and priorities of each major user so that the manager and staff can organize and operate your user interfaces accordingly.

TOOLS AND TECHNIQUES

Having established the mission of the organization and the environment

in which it is going to operate, one can now turn to the tools and techniques which can be applied in this environment in order to meet the stated objectives. In order of importance, top billing must go to the clear and unequivocal definition and acceptance of the responsibilities assigned to the data processing function and to the user. The kinds of questions about which there should never be any debate are:

- identification of projects
- definition of requirements
- determination of benefits
- establishment of priorities both for enhancement of existing systems and the development of new systems
- determination of costs
- operation of existing systems
- project management in development of new systems
- development of long-range application plans

There is no one best way to assign these responsibilities for all organizations. However, the credo "There is no such thing as shared responsibility" will stand one in good stead. Next in importance is the management system viewed from two perspectives. First, the organization of the data processing function must be established with the same principles of unambiguous assignment of responsibility and accountability for the development of new systems, the operation maintenance and enhancement of existing systems and the support services required by each of these major areas.

Second in importance is the external management system. How does one establish effective interfaces between the various levels of management in the user organization and their counterparts in the data processing organization? There is significant merit in having a high degree of symmetry between the data processing organization and the major user organizations. Such symmetry makes possible the establishment of effective communication interfaces at many different levels which not only allows day-to-day problems to be resolved by the people who have the day-to-day problems, but, of equal importance, provides for an orderly process of escalation in both organizations for the resolution of those problems which are not resolved at the lower levels.

THE PLANNING SYSTEM

The planning system can be most effective once objectives and mechanisms have been established. Management of Data Processing planning is probably the most challenging assignment that any individual can conceive. The user community has an infinite level of aspiration and the data processing manager has a very finite level of resource to apply to those aspirations. Recognizing this, it is imperative to establish some

mechanism which, as unemotionally as possible, allows the reconciliation of these two extremes.

In planning it is relatively easy to determine the cost of operation of existing systems and the cost of developing new systems. The one key element which is obviously needed is the value associated with doing either or both of these activities. There are a number of obvious advantages in having the user establish a value on the services being rendered or to be rendered, not the least of which is that it provides a benchmark against which to measure the performance of the data processing function. From the data processing manager's point of view, it provides a rational basis for defining the economic and technical resources which he or she requires in order to meet assigned responsibilities.

Having determined what projects are going to be undertaken within a given plan period, the question of a project management system must be answered. Before deciding on any particular system, it is useful to recognize that the level of review and control which one applies to large or highly visible projects should be different from that which is applied to more or less routine maintenance and enhancement of existing systems. Since there is clearly an administrative cost associated with any project management system, it is important that project management techniques not be indiscriminately applied to projects where the cost of project management overhead is disproportionate to the total cost of the project. In practical terms, one might question the application of the formal project management system to projects of less than 4-6 man-months of effort.

The objective of any project management system is twofold: to provide a continuous and disciplined review of all projects; and to provide for orderly management involvement and support. It is important to have published guidelines which define the project phases and define the responsibilities of the user, the developer, the maintainer and the operator. One technique is to establish a project management team, made up of both user and development people, which takes the responsibility to carry the project from the feasibility stage through post-implementation review. The principle responsibility of the project management team is to ensure that all of the interested or affected parties agree with the project's existence, design and schedule, testing plan, and results and implementation and turnover plan. In other words, effective project management is a system to minimize the potential for surprises and disappointments.

There are obviously other tools and techniques which are essential for the effective management of a data processing facility.

- an effective estimating system
- a resource utilization system which allows the tracking of both development and operations performance against pre-determined plans
- an effective financial control system
- an effective standards and education capability

Standards and education as activities within a data processing department are very naturally aligned. If one thinks of application development as an engineering activity, the requirement for standards becomes very obvious not only from the point of view of efficiency and stability in the creation of the product, but of equal and perhaps greater importance in making possible systems maintenance at reasonable cost over a protracted period of time. The educational tie-in is apparent since most standards are somewhat unique to a given installation. Yet the subject of standards typically gets much less attention from an education point of view than the more classical subjects of programming and analysis.

Typically a new application development area provides the opportunity to take advantage of new technologies in database/data communications or in a structured programming/top down development approach. However, the ability to capitalize on these changing technologies or techniques is contingent upon having an effective standards and education program which anticipates requirements and formulates an effective plan to satisfy those requirements.

Of growing importance to the data processing manager is information retrieval. Information required is often of a summary or analytic nature and, in many cases, represents a one-of-a-kind inquiry or demand. There is a clear trend to simplify the man/machine interface and allow the end user to become much less reliant on static reporting systems which have been built by data processing experts, who probably understood more about the tools which they were applying than they did about the problem to which they were being applied. The consequences of this trend will be quite profound for the data processing manager and staff and will force much more attention to such subjects as data ownership, integrity, control, security and access. A game plan for the distribution of responsibilities between the end user and the data processor in this new environment will become critical.

SUMMARY

In summary, I have attempted to outline the management tools and techniques which one would apply within a particular environment in order to meet a specified set of objectives which have been either established or agreed to by the top management of the enterprise. This same top management needs some mechanism for assessing the performance of the DP unit against these objectives, and, measurement systems vary widely. Regardless, one needs a measurement system which covers at least some of the following considerations:

- final performance
- resource utilization both human and machine
- distribution of resource between new systems and existing systems

- measurement of the amount of resource which is applied directly to projects compared to that which is applied to such things as vacation, education and the like
- measurement of performance against committed schedules

It is also useful to try and develop a profit and loss or cost/benefit statement which continuously monitors the cost, value and payback period or return on investment for all projects undertaken.

There is no cookbook approach to data processing measurement. However, the lack of an effective measurement system within a given installation would have to be construed as a management cop-out. Measurement systems can be devised and their principle value is in forcing of a management attitude toward planning and the measurement of actual performance against those plans. Another significant value of a consistently applied measurement system is its ability to portray trends which stimulate management action, either to rectify the trend or understand the changes behind it and appropriately modify the plans and objectives.

Data processing in many enterprises has graduated from the bush league to the professional league. The essential difference between bush leagues and professional leagues is: the quality of the players; the quality of the competition; the quality of the management; and the quality of the officiating.

Part VI
Communication
and
Innovation

Chapter 19

COMMUNICATION INNOVATIONS: Comets and UFO's

by Gordon Thompson

The year 1974 was supposed to have begun with the century's greatest astronomical display. The comet Kahoutek seemed to capture everyone's imagination, and generated an uncommon amount of excitement. When the great day came, the actual performance of the comet was nothing like the predictions. In fact, it was difficult for even the trained observer to pinpoint the celestial visitors.

In the area of communication innovations, a similar chain of events is distressingly common. The predictions are full of hope, but the actual performance is singularly disappointing. The vast majority of recent communication innovations resemble the comet Kahoutek in this regard.

As if the Kahoutek syndrome were not enough to plague communication innovations, there is yet another threat to their health. If one casts memory back a decade or so, some of the predictions about what the computer might do in terms of information retrieval systems, management information systems, language translation systems, and so on, seemed to have had objectives that were unattainable. So in addition to the class of innovations that were launched and that resembled the comet Kahoutek, there is a second class of innovations that didn't make it because their objectives were either totally frustrating or unobtainable. Unobtainable or Frustrating Objectives — UFO's.

The size of the investment made in developing communication innovations that have either been Kahouteks or UFO's is very alarming. It

is not too difficult to identify well over one billion dollars that have been spent on communication innovations that have turned out to be either Kahouteks or UFO's.

It seems almost as if alchemy rather than science has been used to decide how this effort would be spent. Certainly once these decisions have been made, good science is brought to bear. The Picturephone represents a Kahoutek-like communication innovation of classic proportions. Although good scientific work was done in achieving the objectives, anything but good scientific methodology was involved in deciding what those objectives might be. The development of the silicon target vidicon is an example of the achievements that were made in bringing this service into being. On the other hand, one cannot identify a body of scientific literature dealing with the prerequisites for such a service. Other examples, smaller in magnitude, are not difficult to find. What is missing is an adequate methodology to aid in determining the specifics of new communication services. An equally great need exists for an adequate means of assessing the significance of these innovations. This paper deals with a methodology for assessing communication innovations in order to identify early in the innovations career, whether it is a Kahoutek a UFO, or whether it has the poential of growing into something significant. Although the particular methodology may seem more qualitative than quantitative, it is surely better than alchemy.

IMPACT OF INNOVATION

The measure of significance of past communication innovations must surely lie in the impact these innovations have had on their host societies. The really important innovations, such as writing, the phonetic alphabet, the movable type printing press, and all recent electronic developments, have produced profound effects or impacts on the society in which these innovations occurred. Havelock, in his book *Preface to Plato*, purports that Plato in his *Republic* was really dealing with the effects of the phonetic alphabet on his contemporaries. In order to develop this particular methodology, an analysis was made of the impacts of all previous communication revolutions and a search was made for patterns. The hypothesis is that a significant impact of the same kind that these previous communication revolutions produced, would have produced another communication revolution.

In order to test the technique, an analysis was made of the impact of the first full scale post office strike in Canada. By analyzing the content of reports that appeared in the daily press describing the effects of the service stoppage, and measuring the column inches devoted to the various kinds of effects, researchers were able to determine that the post office shut down produced the highest concern in people's minds in the area of transferring money. Fifty per cent of the column inches describing the effects of the

postal strike were concerned with the difficulties encountered in exchanging bills and payments. Quite clearly, the post office is some kind of bank. In order to check the validity of this concept, an investigation was made to determine who it was that was most interested in the restored service by being first in line at the post office when they opened their doors. In three major Canadian cities, it was the telephone company, with its bags of bills, that go there first and had the most patience. The Canadian cousin of Sears was second. Quite clearly the post office's function as a medium for exchanging money was clearly understood by these two organizations. The post office did not learn this lesson, and today banking networks are beginning to evolve in the world of data communications. It is unlikely that the same situation will develop in the future. Time has marched on and the world has changed.

The above example illustrates how an analysis of effects can identify the important characteristics of a service in terms that may be quite surprising, and far more useful than classical and intuitive notions. Unfortunately, it is difficult to arrange to turn off a telephone company or the television networks, and make a careful set of observations of the results. So a scientific approach based on the stoppage of media seems blocked. Hence it is necessary to appeal to history, and use much fuzzier data from the past. Since it is only recently that scholars have developed any sensitivity for the relationship between social behavior and the communication environment of a society, we cannot expect the historical data to be very precise.

Even when one generates good scientific data on the effects of our new media, others tend to ignore it. The 1972 Pestore hearings into the effects of violence on TV have gone virtually unheeded. In spite of the uncontroversial evidence condemning the practice, violence still continues on TV screens. New media may be too fresh a wound to permit rational assessment and action to be widely accepted. Historical situation, being remote, may be more useful.

CHARACTERISTICS OF COMMUNICATION INNOVATION

The historical analysis, as best it could be done, showed three characteristics that seemed to be present in the really big communication innovations. The first, and perhaps most obvious characteristic that was present in each of these past communication revolutions was that the access to store human experience was always made easier. It was easier to get into the society's collective memory, and more of it was done with each of these significant communication revolution. Clearly writing, the phonetic alphabet, the invention of paper etc. all have this characteristic without question. In order to assess the significance of a change in the ease of accessing stored human experience, it is necessary to develop a test for significance under this characterization. The test that researchers at Bell

Northern have developed relates to the changes in the way people index information as a result of the innovation in question. Consider for example the way referencing was done before the book became popular. In the bible, referencing is accomplished by merely saying, "It is written," whereas after the book became popular it was necessary to detail the page, volume, publisher, author, title and so on so that the actual publication could be identified. The computer produced a host of inter-linked indexing systems and so it had some real impact in this area. Even the telephone book, and yellow pages in particular, has a measurable and observable effect.

The second characteristic is more difficult to grasp and relates to the interaction between the communicants. Consider information as an abstract multidimensional manifold, a sort of hyper-space, with dimensions of language, fields of interest, physical means of communications, etc. The larger the volume in this information hyper-space that two communicants share, the more fully they will be communicating. Each communication revolution seems to have made it easier to share a large and larger volume of this hyper-space with one's fellow communicant. In technical terms, one can say that the size of the common information space shared by the communicants is always increased. The test for significance relates to the range of interrupt strategies open to the communicants. The larger that range is, the larger the space they are sharing.

Clearly if communicants share a plurality of languages, the range of nuances that are open to them is greatly enhanced. As the size of shared vocabulary increases, the ease with which people can communicate increases. Certainly shared experiences further ease the task of communication.

The telephone provides a shared acoustic space, permitting both communicants to talk simultaneously, should they so desire. Echo suppressors, which are used to suppress echo on long distance circuits, tend to destroy that shared space, and Bell Northern has had complaints in the telephone industry from people using the long distance telephone to share a cry with someone else. The echo suppressor, which greatly attenuates the unused, or quieter, direction of transmission, clearly annihilates the shared space and replaces it with a sequential stream of occupancies.

The classical Picturephone service did not create a shared visual space. This I-See-You and You-See-Me kind of thing will not even enhance one's ability to play such a simple game as naughts and crosses. Although it is easy to show a piece of paper on the top of your desk to a friend, that piece of paper will only have the marks that one has made, while the marks the other makes appear not on that piece of paper but on the screen. This means that one has to transcribe what is seen on the screen to the piece of paper in order to get the entire picture of the naughts and crosses game.

This is not to say that naughts and crosses alone provide the utility for a communication system, but the game clearly illustrates the point that a common visual space does not exist with the conventional Picturephone service. One person always has the original and can change it easily while the other person always has only the image of the original, and has to describe changes using conventional telephone techniques.

A sort of super-duper writing surface which at all times shows both parties the sum total of each of their efforts and permits them both to write simultaneously, would provide a shared visual space. Experiments with this type of visual communication have been most exciting, and it will probably be even more significant as techniques in graphics are developed. Researchers at Bell Northern refer to this device as Scribblephone. Scribblephone is actually an interactive intelligent graphics terminal that can be used for man-to-man-and-machine or man-to-man or man-to-machine communication.

The third characteristic which emerged from analysis of the impacts of past communication revolutions has to do with the ease with which shared feelings can be developed about new ideas. Each of these communication revolutions made it easier and cheaper to discover and develop nascent consensus. A word of caution is necessary. It is not the tough hard sort of consensus where three quarters of the population beats the remaining twenty give per cent into submission, but rather the tender beginnings of consensus that are important here. Unfortunately, the English language is not sufficiently developed in this particular area to be able to differentiate between these aspects of the term consensus, hence the adjective "nascent". The test for significance along this characteristic relates to the probability of receiving, or transmitting, a message that is perceived as both unexpected and interesting. This particular characteristic of communication innovations could rightfully command the attention of a lot of study. It has profound impacts in many areas of prime social significance.

COMMUNICATION INNOVATION

In summary then, there are three characterizations of communication innovations of significance that have been developed from an analysis of the impacts of previous communication innovations on their host societies. Together with these three characterizations, tests of significance have been developed which permit a form of ordering of innovations along these characterizations so that some feelings may be developed about the magnitude of the importance of an innovation with respect to these characterizations. One could think of these characterizations as dimensions of a sort of Communication Innovations Space. Although the dimensions are clearly not orthogonal, one still asks are there any constraints that limit the useable volume in this Communication Innovation Space?

It turns out that there are two kinds of constraints. The first constraint relates to a property of language itself, and which the research team has termed the Bar Hillel conundrum. Essentially, Bar Hillel says that the logic of language is more complex than the simplistic class logics of Aristotle. In effect he states that it is impossible to build a truly effective general purpose information retrieval system, for example, but one cannot afford to stop trying; hence the conundrum. Other workers have said much the same thing. Now if one examines the situation, this conundrum lies a dark cloud at the outer end of all of the characterizations. Clearly the conundrum directly addresses the ease of accessing stored human experience, but it equally effects the size of the common information space and the consensus of characterizations. For example, think about the profile that one might write so that the only message received would be messages one will perceive as exciting but unexpected. This constraint relates to the UFO's the Unachievable and Frustrating Objectives. A lot of money was spent a decade or so ago trying to build systems that had objectives that actually lay beyond the constraints imposed by this conundrum. Today researchers seem less naive, and our efforts seem to be towards innovations that hit the other constraint.

The second constraint is a kind of economic one but really deals with the container of economics rather than with economics itself. Past communication innovations that have had any real significance have appeared to open the otherwise closed economic system for a brief period of time, making that system have characteristics that seemed less like "zero sum" games, and more like the "everybody wins" game. In effect, the cost of the communication innovation was small compared to the wealth that it created throughout the society, within a few decades. Two of the three characterizations, that is the consensus one and the ease of access to stored human experience, appear to relate to this wealth creating property of the big communication innovations. The innovations that fail to pass this test, are the Kahouteks.

In a spherical coordinate system, one can assign the three characterizations to the coordinate system dimensions so that the lower limit of the two dimensions represented by the second constraint, in combination with the upper limit imposed by the Bar Hillel conundrum, produces a real solid. The shape of that solid is essentially that of a doughnut with a small sector removed. The UFO's or the Bar Hillel constrained innovations, lie beyond the surface of the doughnut while the comets lie in the hole in the middle of the doughnut. The sector that is removed from the doughnut results from the interaction of both constraints with the rotational dimension. With this model, the rotational dimension corresponds to the ease of discovering and developing consensus, while the elevation angle represents the size of the common information space shared by the communicants, and the distance out the radius sector indicates ease of accessing stored human experience. Again,

the comets, or Kahouteks, like in the hole of the doughnut, and the UFO's, or the linguistically constrained innovations, lie beyond the doughnut.

This model has been very useful in identifying whether or not the inventing has been completed in an innovation. One can use this assessment tool as a means of fine tuning an innovation in order to enhance its probability of success. Researchers at Bell Northern have used the technique for creating scenerios of the "son of the telephone." Such scenerios are very useful in identifying, on an a priori basis, the antecedents for such a concept. In some cases, research that has been very surprising and rewarding has been found as a result of using this methodology, research that never would have been uncovered any other way. This tool has proven very valuable in terms of adjusting perceptions away from one's trained and intuitive biases. Bearing in mind that the communications industry is one hundred years old, and has evolved into a very mature business, research and development must lead either to replacement of the business itself or developing mere efficiency within the existing business. The last century was spent on the latter activity, and traditional training in research hardly qualified one to deal with the former issue. Tools of this type are mandatory if researchers are to do this work with any hope of success.

In effect, the research team at Bell Northern is trying to exorcise the alchemy from work in the new service area. This tool is a first step in doing just that. Other steps, other tools, will be necessary to get out of the twilight of the alchemy that produces the UFO's and Kahouteks and go on to develop really rational strategies for evolving new communication, yes and new computer system innovations. The universities can help themselves by working hard in this area.

Appendix A

Catalogue Record 1

PART NO.	CAPACITANCE μF	TYPE DESIGNATION	DIMENSIONS						APPROX PRICE EACH
			As 1/16"	Bs 1/16"	Cs 1/8"	Ds 1/32"	Es 1/16"		
190-50-500-720	.1 - .1	CP5385EF104V1	1-13/16"	1"	7/8"	2-1/8"	2-1/2"	2.89	
190-50-500-722	.25 - .25	CP5385EF254V1	2"	1-3/4"	7/8"	2-3/8"	2-3/4"	3.61	

CIRCUIT DIAGRAM

NOTE:

1. TOLERANCE: +20% -10%
2. INSPECTION REQUIRED
3. SEE INFORMATION SHEET VI OF GROUP 190 FOR EXPLANATION OF TYPE DESIGNATION

M.R.C. RADIO & E.E. DIV. STANDARD PARTS		CAPACITORS	
		OIL FILLED, BATH TUB.	
		THREE UNITS, 500 WVDC. (MIL-C-23)	
DECEMBER 1973	Approved: <i>WFL</i>	Type: 50-500	Group: 190

Form R-20
revision 3

Appendix B

Catalogue Record 2

PZ4 M65	Miller, Walter M	A canticle for Leibowitz. New York, Bantam Books, Inc., 1959 [reprinted 1972]	278p.	18cm.	
xMain					
OON PZ4 M65	Miller, Walter M	A canticle for Leibowitz. New York, Bantam Books, Inc., 1959 [reprinted 1972].	278p.	18cm.	
xMain					
PZ4 M65	Science fiction. Miller, Walter M				1959
		A canticle for Leibowitz. New York, Bantam Books, Inc., 1959 [reprinted 1972].	278p.	18cm.	
xMain					
PZ4 M65	A canticle for Leibowitz. Miller, Walter M				
		A canticle for Leibowitz. New York, Bantam Books, Inc., 1959 [reprinted 1972].	278p.	18cm.	
xMain					
PZ4 M65	Miller, Walter M	A canticle for Leibowitz. New York, Bantam Books, Inc., 1959 [reprinted 1972].	278p.	18cm.	
xMain					
PZ4 M65	Miller, Walter M	A canticle for Leibowitz. New York, Bantam Books, Inc., 1959 [reprinted 1972].	278p.	18cm.	
xMain					
Admin.		Parts of this book appeared in a different form in the Magazine of fantasy and science fiction, 1955.			
Aero.					
Biol.					
Bldg.					
Chem.					
Phys.					
Radio					
Sumsex					
Upda.					

AH/ag

Appendix C

Sample of Student Dialogue Histology Course

EXAMPLE 1. STUDENT FLOW

histl

- COMPUTER: 1. Study slides 1 and 2. Then type the name of the organ.
STUDENT: Stomach
COMPUTER: No. The lamina propria of the stomach is packed with tubular glands and the epithelium is of a single cell type. Try again.
STUDENT: Small bowel
COMPUTER: No. Look closely at slide 2. What you probably assumed were villi are straight tubular glands. Notice the numerous light staining cells in the epithelium. Try again to name the organ.
STUDENT: Anal canal
COMPUTER: No. Observe the four layers in the wall of this organ—mucosa, submucosa, muscularis, and serosa. This is highly indicative of the alimentary canal. Name the organ.
STUDENT: Esophagus
COMPUTER: No. Notice the large number of goblet cells in the mucosa and the absence of villi. Try Again.
STUDENT: Large Intestine
COMPUTER: Correct. The characteristics you should have observed were crypts of Lieberkuhn with a large number of goblet cells present as well as the absence of villi.

EXAMPLE 2: STUDENT FLOW

histl

- COMPUTER: 12. The following is a list of tissues and structures that are present in this tubular organ. Study the list and name the organ described.
1) Noncornified stratified squamous epithelium
2) A Layer of longitudinal muscle bundles
3) Glands sometimes present in the lamina propria and/or submucosa
4) Circular and longitudinal muscle layers in the outer coat
STUDENT: Vagina
COMPUTER: Wrong. The vagina contains stratified squamous epithelium but the muscular coat in the vagina is composed of interlacing longitudinal, circular, and oblique muscle fibers rather than two distinct layers as in this organ. Also, there is no muscularis mucosa in the vagina. Try again.
STUDENT: Esophagus
COMPUTER: You are correct. Look at slides 16 and 17. Remember that most of the sections of esophagus you will see have only one type of gland and often there are no glands present.

Appendix D

Student Sample Flow-TES The Independent Study Program

<i>Student - Computer Dialogue</i>		<i>Comments</i>
Computer:	Name the pathological conditions within the brain caused by blockage of the lateral and medial foramina of the inferior medullary vellum.	Computer asks question No. 7
Student:	I don't remember	Student responds (un-anticipated response)
Computer:	Are you having difficulty placing the location of the inferior medullary velum and/or the significance of the foramina?	Computer poses review question
Student:	Yes	Student responds
Computer:	The inferior medullary velum forms part of the roof of the fourth ventricle. The foramina communicate with the cisterna magna and/or cisterna pontis. What is contained in these cisternae?	Computer offers coaching information and poses another question
Student:	Cerebral spinal fluid (CSF)	Student responds (correct answer)
Computer:	Correct. Now consider blockage of the foramina and answer the original question.	Computer gives reinforcement to correct answer
	Name the pathological conditions within the brain caused by blockage of the lateral and medial foramina of the inferior medullary velum.	Computer re-poses original question
Student:	Water on the brain	Student answers (wrong answer)
Computer:	Not acceptable. It's time to become more professional in your terminology!	Computer offers tutorial feedback pointing to correct answer.
Student:	Hydrocephaly	Student responds (correct answer)
Computer:	Very good!!! The obstruction will cause an increased quantity of cerebrospinal fluid in the ventricular system.	Computer gives reinforcement to correct answer

Appendix E

SOCRATES Form

SOCRATES CALIFORNIA STATE UNIVERSITY AND COLLEGES USER IDENTIFICATION PAGE - (REQUIRED)

Type of Transaction	1	1
Page Number	01	2-3
Name	Last F I M I	4-19
Social Security Number		20-28
Campus Number		29-30
Campus Name		31-48
Department Identification e.g., BIOL for Biology		49-52
Course Identification Number for which this test was (is being) made.		53-57

Test Number (This number is teacher assigned. You must assign a different number for each test within a course, but you may use the same number for different courses. Whenever a modification is made, you must fill in the number you assigned to the test being modified.)

		58-59
Item Bank		60-64
Number of Additional Versions of Test Desired		65

SOCRATES
CALIFORNIA STATE UNIVERSITY AND COLLEGES
SPECIFIC QUESTION REQUEST PAGE

(Use additional pages as needed)

Type of Transaction	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td></tr> <tr><td style="width: 10px; height: 15px;"></td></tr> <tr><td style="width: 10px; height: 15px; text-align: center;">3</td></tr> </table>			3	1	
3						
Page Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td></tr> <tr><td style="width: 10px; height: 15px;"></td></tr> </table>			2-3		
1st Four Characters of Last Name	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					4-7

If there are specific questions that you want to be included in this test, list the Subject Category Number and Internal Question Number of each below. If there are none, do not submit this page.

Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					8-12
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			13-14		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					15-19
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			20-21		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					22-28
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			27-28		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					29-33
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			34-35		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					36-40
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			41-42		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					43-47
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			48-49		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					50-54
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			55-56		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					57-61
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			62-63		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					64-68
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			69-70		
Subject Category Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>					71-75
Internal Question Number	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 10px; height: 15px;"></td><td style="width: 10px; height: 15px;"></td></tr> </table>			76-77		

SOCRATES
CALIFORNIA STATE UNIVERSITY AND COLLEGES
TEST REQUEST PAGE
(Use additional pages as needed)

Type of Transaction	4	1
Page Number	1	2-3
1st Four Characters of Last Name	1 2 3 4	4-7
REQUEST TEST SUBJECT:		
Category Number	1 2 3 4 5 6 7 8 9 0	8-12
Quantity of Items	1 2 3 4 5 6 7 8 9 0	13-15
Keyword Category	1 2 3 4 5 6 7 8 9 0	16-19
Special Characteristic	1 2 3 4 5 6 7 8 9 0	20-21
Question Difficulty Level ¹	1 2 3 4 5 6 7 8 9 0	22
Behavior Objectives of Item ²	1 2 3 4 5 6 7 8 9 0	23
Item Characteristic Suppression ³	1 2 3 4 5 6 7 8 9 0	24
REQUEST TEST SUBJECT:		
Category Number	1 2 3 4 5 6 7 8 9 0	25-29
Quantity of Items	1 2 3 4 5 6 7 8 9 0	30-32
Keyword Category	1 2 3 4 5 6 7 8 9 0	33-36
Special Characteristic	1 2 3 4 5 6 7 8 9 0	37-38
Question Difficulty Level ¹	1 2 3 4 5 6 7 8 9 0	39
Behavior Objectives of Item ²	1 2 3 4 5 6 7 8 9 0	40
Item Characteristic Suppression ³	1 2 3 4 5 6 7 8 9 0	41
REQUEST TEST SUBJECT:		
Category Number	1 2 3 4 5 6 7 8 9 0	42-46
Quantity of Items	1 2 3 4 5 6 7 8 9 0	47-49
Keyword Category	1 2 3 4 5 6 7 8 9 0	50-53
Special Characteristic	1 2 3 4 5 6 7 8 9 0	54-55
Question Difficulty Level ¹	1 2 3 4 5 6 7 8 9 0	56
Behavior Objectives of Item ²	1 2 3 4 5 6 7 8 9 0	57
Item Characteristic Suppression ³	1 2 3 4 5 6 7 8 9 0	58
REQUEST TEST SUBJECT:		
Category Number	1 2 3 4 5 6 7 8 9 0	59-63
Quantity of Items	1 2 3 4 5 6 7 8 9 0	64-66
Keyword Category	1 2 3 4 5 6 7 8 9 0	67-70
Special Characteristic	1 2 3 4 5 6 7 8 9 0	71-72
Question Difficulty Level ¹	1 2 3 4 5 6 7 8 9 0	73
Behavior Objectives of Item ²	1 2 3 4 5 6 7 8 9 0	74
Item Characteristic Suppression ³	1 2 3 4 5 6 7 8 9 0	75

1. Difficulty Level Key—
— 3 for easy
— 5 for average
— 7 for hard
— blank for a mix

2. Behavior Objectives Key—
— 1 for knowledge
— 2 for application of knowledge
— blank for a mix

3. Suppression Key—
— 1 no reserve
— 2 no rehearsal
— 3 neither reserve
nor rehearsal
— blank for a mix

SOCRATES
CALIFORNIA STATE UNIVERSITY AND COLLEGES

QUESTION DELETION PAGE

(Use additional pages as needed)

Type of Transaction	2	
Page Number	1	
1st Four Characters of Last Name	2-3	
Enter a 1 here to delete all questions currently on the test.	4-7	
Enter a 1 here if you want the deletions listed on this page to be replaced. If so, new questions will be selected according to the attributes specified in the request block which was originally used to select the deleted question.	8	
Enter the test question number of each question you wish to delete in the boxes supplied at the right. Enter zeroes in the leading spaces. For example, if you wished to delete question 3, you would fill in the box as follows	9	
	10-12	
	13-15	
	16-18	
	19-21	
	22-24	
	25-27	
	28-30	
	31-33	
	34-36	
	37-39	
	40-42	
	43-45	
	46-48	
	49-51	
	52-54	
	55-57	
	58-60	
	61-63	
	64-66	
	67-69	
	70-72	
	73-75	
	76-78	

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